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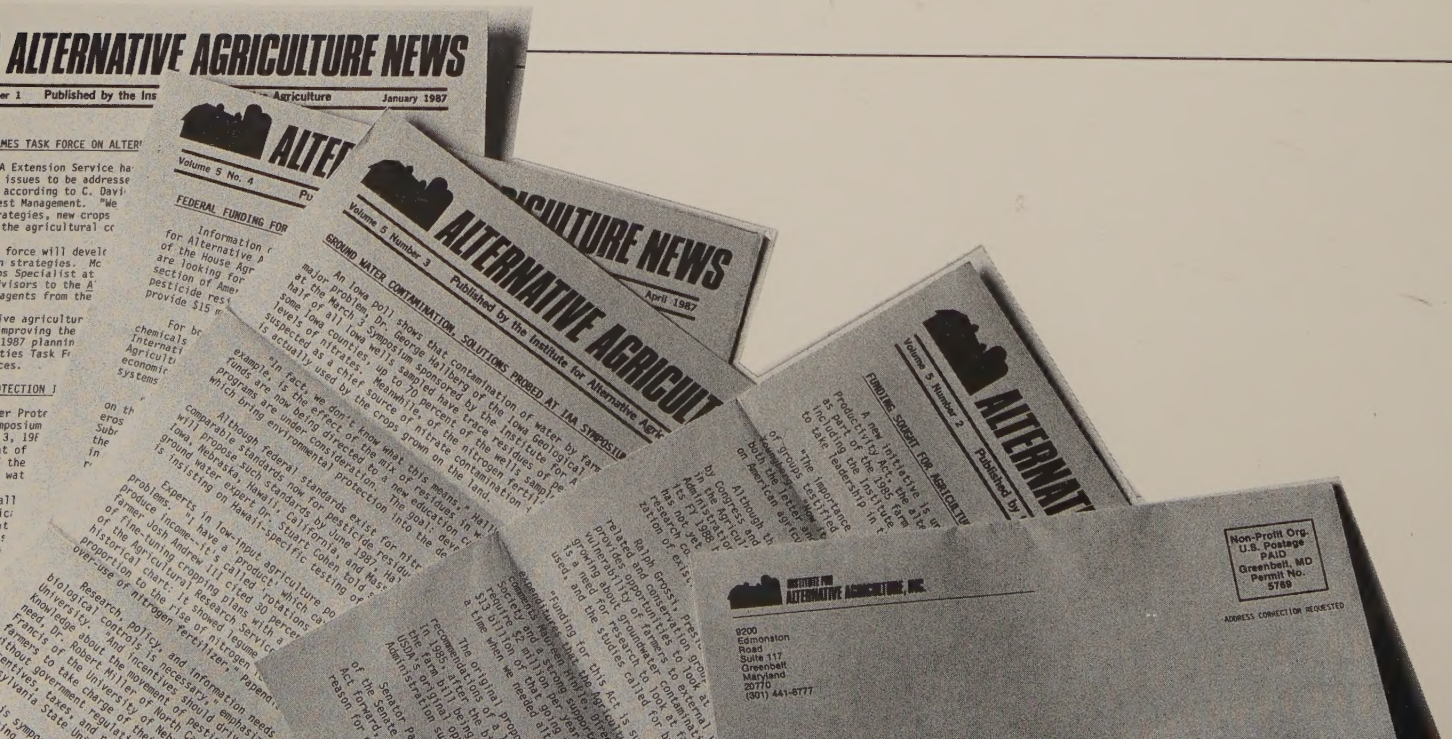

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TABLE OF CONTENTS

Articles

101 Toward a sustainable agriculture: Need for clarification of concepts and terminology
Dennis R. Keeney

106 Low-input farming in practice: Putting a system together and making it work
Frederick Kirschenmann

111 Crop rotation efficiencies and biological diversity in farming systems
David F. Bezdicek and David Granatstein

121 The role and contributions of animals in alternative agricultural systems
Frank H. Baker and Ned S. Raun

128 Widespread adoption of non-conventional agriculture: Profitability and impacts
Sandra S. Batie and Daniel B. Taylor

135 Policy barriers to sustainable agriculture
Douglas L. Young

144 Implications of low-input farming systems for the U.S. position in world agriculture
John E. Lee, Jr., and Kenneth Baum

153 Sustainable agriculture: Policy options and prospects
Charles M. Benbrook

160 Environmental reform of agricultural policy in 1990 and beyond: Consider the source
Kenneth A. Cook

167 Converting stewardship values into policy: The mission of the 1990 Farm Bill
Ron Kroese

169 Commentary: How organic producers can make classical biological control work for them
R. G. Van Driesche

173 Commentary: Trees and sustainable agriculture
Peter R. Schaefer

Departments

Opinion—98 • Institute News—119 • Upcoming Events—143 • Book Reviews—180 • From the Literature—185 • Letters—187 • Resources—188 • Special Report—190

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Institute Information

The Institute for Alternative Agriculture is a nonprofit, tax-exempt research and education organization established in 1983 to encourage and facilitate the adoption of low-cost, resource-conserving and environmentally-sound farming methods. It works closely with producer groups, public research and education institutions, and government agencies in promoting a sustainable agriculture system.

Its programs include providing a national information clearinghouse, serving as a voice for sustainable agriculture in Washington, and developing and implementing research and educational outreach programs. It holds an annual scientific symposium and publishes a monthly newsletter.

The Institute is governed by a grass roots Board of Directors, which includes several commercial-scale organic farmers, and maintains a small professional staff. It is supported by memberships and donations and grants from foundations, corporations, and individuals.

Cover Photo

The cover photo depicts a harvest scene on the Kirschenmann Family Farm in 1988, the worst drought on record in North Dakota. The diverse crop and livestock system on the Kirschenmann farm, using crop rotations, natural soil building and water conservation strategies common to many sustainable systems, yielded an income during this drought year that was 80 percent of normal. Many continuous, mono-cropping conventional farmers in the area never started up their combines.

OPINION

Sustaining agriculture and development: Challenges for the future

Charles A. Francis

Agricultural scientists hold some of the pieces to the complex puzzle of how food production can be sustained into the future. This includes integration of knowledge from basic biological sciences with practical results from adaptive field research. The global challenge is to use this knowledge to confront the growing dilemma of how to intensify agriculture with a diminishing fossil fuel resource base, how to feed an exploding human population, and how to protect the environment.

To achieve this will require an adjustment in thinking about agricultural development beyond that of the perspective involved in the human domination of nature with industrial, chemical-dependent technology. A philosophy of food production and development is emerging that depends on intensive and efficient use of renewable resources, elevates information and management as substitutes for non-renewable energy-based resources, and seeks a balance with nature that allows a good quality of life for humans and the survival of most other species. I suggest ten ways to translate this philosophy into practical programs.

Encourage interdisciplinary research

Despite the growth of interdisciplinary research, task forces, teams, and integrated centers, the majority of professional time is still dedicated to narrow subject matter areas. Most agricultural scientists have been unwilling, unprepared, or lacking in confidence to deal with the complex, larger questions in development.

There are many reasons for this narrow focus. Professional orientation and training have concentrated on specific disciplines. Formal course work and dissertation research restrict the exposure to ideas, methods, or results from other departments. What we develop are discipline-specific words, meanings, and dialects, narrow groups of professional contacts, and a world view that considers one's own field, whether soil chemistry or genetic engineering or basic biotechnology or any other to hold key answers to most of humankind's current and future problems. Professional reward systems - advancement and salary increases - are dependent on peer review within specific disciplines and administrative analysis of refereed publications. Young scientists are rarely encouraged to think broadly about global issues. Today's agricultural scientists are products of the professional environment.

Is it possible to move beyond this narrow focus on problems within disciplines? Can scientists learn to explore new ways to fit the puzzle pieces together? Are there methods and measurement tools that can contribute to more effective evaluation of the broader impacts of specific technologies? Interdisciplinary teams are needed to address these complex problems. The broadening of outlook gained by working with different specialists helps each participant to view cropping and farming systems in a more holistic way. This is a valuable stride toward interpreting research results in a long-term global perspective.

Explore innovative farming systems

Rather than carefully fine tuning present monoculture (single species) cropping systems, such as continuous corn production, scientists need to explore more complex systems that are productive and sustainable, often more so than conventional systems. Yet university specialists persist in comparing monoculture with multiple cropping, or continuous corn with rotation crops. This could be called "agronomic trivial pursuit." Resources can better be spent studying and exploiting rotation effects and biological diversity, seeking more sustainable systems based on renewable resources, and attempting to mimic stable natural systems. A diverse mix of crops and enterprises will lead to a better distribution of labor use through the year. Such systems also protect against drastic changes in climate, input costs, and prices of individual commodities.

Evolve from "product use" to "problem solving process" mentality

Heavy reliance on technology to solve problems in agriculture has promoted a "product mentality." When a farmer has weeds in the soybean field, the first question to extension specialists is probably, "What herbicide can I spray to kill the weeds

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A more logical, process-oriented approach would be for the farmer and extension specialist to study the kinds, sizes, and numbers of weeds in the field and stage of the crop, and then to evaluate a range of management options. Herbicide application is only one of many alternatives. To follow "process" further, it is important to determine what characteristics of the system have allowed weeds to become a problem and what modifications could reduce the density or germination of weed seeds. It often is possible to substitute information or management for a purchased input, thus reducing production costs and the potential for environmental contamination.

Combine linear planning with cyclical thinking

Farmers typically plan their cropping sequences, input use, and cultural practices in a straight-line manner through the crop year and into subsequent years. This means that when soluble fertilizers or pesticides are applied, the farmer assumes that they either are used by the crop or remain where they will not be harmful. Also, if some materials move into an aquifer or downstream, they have gone beyond the boundaries of traditional farmer concern. But in today's world, everyone lives downstream and within the same global boundaries and cycles of water and nutrients.

Monoculture systems represent a "linear species approach" to input use and cropping, whereas crop rotations and diverse systems promote greater cycling of nutrients. They also stimulate thinking about the natural cyclical processes in the system. Understanding nutrient cycles, hydrologic patterns, biological interactions, and natural species succession is part of the process. Intensive human involvement and management of each field provide an appreciation of the farming system and how its components fit together.

Involve professional women in agriculture

Women are hardly at all involved in the administration and technical sector of agriculture, even though in many cultures they make many production decisions, especially for horticultural crops. This means that in the critical game of food production, planning and research, half the team is off the court. Indeed, in some countries, women have not even been invited to the game. Yet the missing female players are perhaps the very ones who can see the problems more broadly and who can integrate the quest for production with needs for nutrition, health, and quality of life. Redressing their under-representation in research and extension is neither a woman's nor a man's problem; it is a human challenge.

Understand the fragility of the natural environment

Until there is broader appreciation of the sensitivity and fragility of the natural environment that sustains human life, it is unlikely that most people in agriculture will seriously challenge the sustainability of the current "domination mentality." Warning signals on the farm and in the community include loss of soil, chemical contamination of water systems, and disappearance of wildlife habitat. On the world scene, there is loss of the ozone layer, a worldwide warming trend, destruction of the tropical rain forest, and non-degradable wastes in the oceans. Can we expect all these problems to be solved with a new product or application of another fossil fuel-dependent technology? Is it likely that the effects of that technology are neutral to the environment? Developing new technologies and getting farmers to adopt them has been easier than evaluating their long-term impacts on the environment. We need not only to assess carefully both the benefits and the costs of each technology, but also to have the courage to leave some of these advances "on the shelf" for now. As a popular bumper sticker states, "Nature Bats Last"!

Adapt to the reality of finite fossil fuels

Most agricultural research continues to pursue solutions that depend on fossil fuels. This strategy has often been highly successful, increasing productivity per unit land area, per human, and per unit of labor invested in agriculture. As population continues to increase and resources become scarce, it is time to answer an even greater challenge: how to live within this constraint and design a food system that will be sustainable for the future.

The needed strategy will maximize efficient use of renewable resources - soil nutrients in organic and mineral fractions, rainfall, solar energy - while using fossil energy only when it is absolutely essential. This strategy preserves non-renewable energy sources for the indefinite future for uses where no alternative can be found. Other sectors outside of agriculture - transportation, heating and cooling systems, food preparation, industry - must seek similar solutions.

Accept responsibility for broader issues

Most agricultural scientists view their role as contributing basic knowledge in specific disciplines. This view has created a generation of competent but narrowly focused technicians. Is it possible to break from this pattern and become involved in broader, long-range issues facing humankind?

The first step is to become aware that larger problems exist than can be addressed in each department. The second is to gain confidence that specialists can make useful contributions in wider arenas. Scientists often discuss problems larger than those in their own fields but then retreat into jobs where they feel more secure. It takes courage to move beyond the traditional role of agricultural scientist.

Extend the time frame to consider longer term solutions

Most human activity and thinking take place in the here and now. Research must be planned toward the time when results will be available to integrate into practical production systems. This takes at least 3 to 5 years with most agronomic research and 10 to 15 years in plant breeding. Therefore, it is crucial to anticipate what primary systems will look like a decade or two from now. How will new component technologies fit together? Is it possible today to anticipate the resource constraints and economic/environmental incentives that will prevail after the year 2000 and to develop technologies appropriate for them? Why not design the future? The projection of current trends is a shallow and fatalistic approach. Human ingenuity makes it possible to plan what kind of future we want and to decide what types of food and industrial systems would provide for basic needs and a broader quality of life and then take steps to make that future happen.

Broaden human focus to the global community

Agriculture is a competitive business. It must compete for

(continued on page 192)

Sustainable farming systems: Needs and opportunities

Issues related to the sustainability of American agriculture are now leading to developments describable as a major evolutionary leap forward in farming research, education, and practice across the nation. Ten years ago, the term "sustainable agriculture" was unknown. Today, it is in the title of countless research and education programs, policy proposals, speeches, and articles. The pressures giving rise to this change in direction and in focus are rapidly becoming commonplace knowledge in the farm community: water contamination; soil erosion; questions regarding the safety of foods; economic insecurities, and more. Still in the process of discovery, however, are viable production alternatives to unsustainable practices - alternative systems suited to a wide variety of climates, soil conditions, and economies.

Many definitions of sustainability have been articulated. They include factors concerned with the natural resources of soil and water, but also accountability for ecological processes and for economic and social health in the long term. Although a consensus is growing around the idea that a new level of sustainability should be an overall goal for American agriculture--the alternative is unthinkable--we are yet a long way from knowing just what methods and systems in diverse locations will really lead to sustainability. Organic agriculture, soil-conserving methods such as conservation tillage and crop rotations, methods of integrated pest management, and what is now being called "low-input" farming--all are important parts of that picture. In many regions of the country, however, and for many crops, the particular mix of methods that will allow curtailing use of harmful farm chemicals or building crop diversity, while also providing economic success, are not yet clear. The stage is set for challenging not only farm practitioners, but also researchers, educators, and farm industry.

In the United States, the debate over the next five-year federal formulation of farm policies in the 1990 Farm Bill provides one focus for discussion about ways to achieve the goal of sustainability. In this regard, it now seems fairly likely that new legislative provisions will allow for more sustainable cropping methods such as crop rotations. Existing federal policies favor crop monocultures, with concentration of acreage in crops protected by the safety net of federal payments. Unfortunately, however, the micro and macro effects of such changes are not always clear.

Factors such as concern of environmentalists about soil erosion and water pollution, and consumer responses to reports of food contamination by farm chemicals, will also affect policy directions and viability. Unfortunately, sustainable farming systems, the barriers to achieving them, and the effects of moves toward sustainability are not fully understood. Good poli making will demand extensive information and ideas from broad sector of experts, including practicing farmers.

In any time of great change, it is essential that communit come together to share their knowledge and their questions, think broadly about the overall issues they face, and to cha future directions. In the best of such gatherings, voices fro many parts of the community are heard and consideration given to both broad issues and to the real problems and p tentials seen from the angle of the practicing land user.

It was from this perspective that the Institute for Alternati Agriculture convened its symposium on Sustainable Farmi Systems in Washington, DC, on February 28, 1989. The pr gram, the sixth in the Institute's annual series, included searchers and educators, farmers and farm advisors, public a private sector representatives, environmentalists, and econ mists. The papers that appear here, first presented at that sy posium and later peer reviewed and then refined by th authors, provide viewpoints from all of those perspectives, bo on the current situation and on paths that promise to be fruit if followed into the future.

We wish to point out that this is the second time we ha included two Journal numbers in a single issue. As was t case in 1988, the material greatly exceeded the Journal's norm length. In our view, publication of these papers in two separa issues would have made it impossible to capture the sense wholeness present at the symposium.

Finally, we note that the two articles appearing in the Co mentary Department are not part of these symposium pr ceedings. They do, however, address important related aspe of some of the technological and policy themes raised in t symposium papers, thus providing excellent additional food thought as we continue to search for answers to a broad ran of sustainability issues and questions. It is our hope that th papers will be helpful to the larger agricultural community it considers directions for the future.

The Institute's board and staff thank Pioneer Hi-Bred ternational, Inc., for its financial support of this issue of t Journal. We also thank the members of the symposium or nizing committee: Otto Doering, Charles Francis, Willia Lockeretz, Ned Raun, and Katherine Reichelderfer. In ad tion, we gratefully acknowledge the splendid cooperation of t authors and the many anonymous reviewers of the symposiu papers.

Garth Youngberg and Richard Harwood, Symposium Chairs

Toward a sustainable agriculture: Need for clarification of concepts and terminology

Dennis R. Keeney

Abstract. *Recently there has been a change in thinking among many agricultural leaders and researchers toward a major focus on agricultural sustainability. To make progress toward such sustainability requires a clear delineation of its concepts and components. In this paper, I attempt to clarify relevant concepts and terminology in an effort to facilitate communication and cooperation. I also recognize, however, the intense feelings involved in these definitions. More satisfactory definitions will come in time as research and practice continue.*

Key words: soil erosion, fertilizers, pesticides, biotechnology, policy, education

Introduction

Concerns about sustainability have evolved from the status of a minor consideration in the conduct of U.S. agriculture before the first Earth Day in 1969 to that of a major theme in the 1990 Farm Bill debates. This change is perhaps best illustrated in a 1989 publication from the National Research Council entitled *Alternative Agriculture* (NAS, 1989).

Because the concept of sustainability is so dramatically different depending on the aspect in which it is viewed, a precise definition is and will probably continue to be elusive (Carter, 1989; Francis et al., 1989; Lockeretz, 1988; Ruttan, 1988; York, 1989; Hamilton, 1989; Stinner and House, 1989; Francis and Hildebrand, 1989). Differences in viewpoint and aims among individuals and groups involved in agriculture, whether they be from the input, production, or marketing sector, have understandably led to inconsistency and confusion with respect to the meanings of "sustainability" and related terms. I will attempt here to define the relevant concepts and terms in a manner conducive to progress in research outreach and farm practice.

Members of groups concerned with agricultural sustainability must have more than a vague concept of "sustainability" if they are to make real progress. They need a workable definition, one that can be tested scientifically and transferred to farmers. The working definition will ultimately come from the on-farm research programs that develop and demonstrate sustainable practices (King et al., 1989; Francis et al., 1989).

Nature and extent of confusion regarding sustainability

Much discussion has appeared recently in popular and agricultural trade publications about the meaning of the terms involved with sustainability. Concern has centered on profitability, but many articles have been critical without examining the sustainability concept in depth. The effect has been to promote confusion, concern, and even hostility among agricultural professionals in mainline agricultural and commercial organizations. As a result, the credibility of research and outreach programs specifically oriented toward sustainability is low in some areas. The above-described situation is unfortunate because it detracts from the achievements of individuals, institutions, and private industries concerned with sustainable agriculture and involves the use of energy and resources on internal debate at a time when people in agriculture should stand together to advance the agenda for a competitive approach to farm production while maintaining natural resources and the rural social fabric (Brown, 1989).

In spite of the above-mentioned problems, however, the current situation has advantages in that it forces all who espouse sustainability to attempt to define and scientifically defend their methods and conclusions. The sustainability issue is thereby prevented from becoming a bandwagon process. Areas are clearly provided for debate on the future of agricultural research and federal farm policy.

In part, confusion arises because of the large number of synonyms, semi-synonyms, and alternative terms that have appeared recently. These include, but are not limited to, "low-input sustainable agriculture (LISA)," "alternative agriculture," "organic farming," "regenerative farming," "best management practices," and "maximum economic yield."

Perhaps the term least acceptable to the input industries, particularly to the agrichemical industries, is the "low-input" portion of the USDA LISA program (e.g., Ruttan, 1988). This term has resulted in accentuated criticism of sustainable agricultural endeavors. As the LISA program develops a base of scientific knowledge, such criticism will di-

Presented at Institute for Alternative Agriculture Symposium on Sustainable Agriculture, February 28, 1989, Washington, DC.

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minish; but concern over combining "low-input" with sustainability will probably continue. It is noteworthy that the current funding of $4.45 million nationally is very small relative to the impact and attention that LISA has been receiving. One of the roles of relevant organizations is to examine the sustainability concept and to find a place for sustainable research in the mainstream of agricultural research and practice.

Sustainability concepts

My working definition of "sustainability" is: "agricultural systems that are environmentally sound, profitable, and productive and that maintain the social fabric of the rural community." Perhaps Wendell Berry said it best years ago when he defined sustainable agriculture as "agriculture that does not deplete soils or people" (Jackson et al., 1984). I am certain, although without proof, that many Iowa farmers' operations are truly sustainable and have been so for generations. Farmers that are using their internal resources, including soil fertility, labor, and management skills to the fullest extent are probably practicing the kind of land stewardship that will help define sustainable agriculture. These farmers often are early adoptors and excellent managers and have high returns on their investment in land and labor. The *Alternative Agriculture* report (NAS, 1989) attempts to assist in the definition of sustainability by use of case studies.

A shorthand definition of sustainability is "forever." The long-term future of the nation, indeed of the world, must involve consideration of the future of irreplaceable resources, i.e., soil, air, and water (King et al., 1989). Topsoil is particularly critical because of its slow rate of regeneration and its proven effects on crop yields, resistance to water stress, and degradation of pollutants. Current soil conservation programs are tied to reducing soil loss by restricting erosion to the "T" (tolerable) value as defined by the Universal Soil Loss Equation. Others argue forcefully that soil loss should be held to essentially zero (Larson, 1981). In any case, there is no question that many agricultural regions cannot lose soil at the tolerable or greater level without affecting long-term crop yields (Larson, 1981; Larson et al., 1982; Phipps and Crosson, 1986). Further, off-site effects of erosion involve a major societal cost.

Operational definitions of sustainability

The operational concept of sustainability is undoubtedly the place where the greatest conceptual difficulties arise. Management decisions at the farm level must be made with profitability in mind, including utilizing government commodity programs most effectively. Farming is basically a highly risky venture due to adverse effects of weather and pests; lower inputs, however, may lessen risk of financial loss due to crop failures (Duffy, 1989; Stinner and House, 1989) assuming the government does not step in with massive aid programs as in the 1988 drought aid program.

Many factors will undoubtedly play a role in sustainability at the farm level. One of these is farm size. Another is the role of the farmer as opposed to that of the farm manager-landlord. Is sustainability related to farm size? This critical question needs scientific examination. Another question relates to how one may modify farm operations to maximize use of resource-conserving technologies.

The concept of sustainability embraces the landscape and the biota, the interconnections in nature regionally and globally (NAS, 1982; Odum, 1989). Landscape-level decisions are essential to address sustainability. In contrast, a more narrow concept of sustainability involves thinking at the disciplinary, field scale level. An example is "Maximum Economic Yield." People addressing this concept examine maximizing efficiency of inputs in relation to maximum outputs without examining the long-term environmental and social costs associated with the outputs. While they may be advancing concepts useful to the individual farmer, they may easily miss broader aspects of farm problems (King et al., 1989; Odum, 1989).

This is not to criticize unfairly the private industries that promote th technologies; industry is not char with environmental protection at the gional scale. If it were, we would need governmental units with that n sion. Industry must turn a profit. question facing us in the 90's and beyo is how to provide the type of agricultu input technologies, products, and s vices that permit agriculture to be co petitive and profitable at the individ farm level and, at the same time, to p tect the environment and the social f ric of rural communities. Industries n to promote reasonable, responsible te nologies that will permit them to t an active role in new and ecologica sounder societal goals (Duvick, 198

Industry produces what the pul thinks it wants. Sustainable agricult oriented institutions must evaluate entifically the problems of the pres and future in agriculture and trans these findings to industry, the taxpay and the decision maker.

Key components of a sustainable agriculture

Agronomic

A sustainable agriculture must founded on sound agronomic princip Soil erosion control, weed manageme maximum efficiency of on-farm and p chased inputs, minimal leaching of p lutants through the root zo maintenance of soil fertility by pro addition of plant nutrients, and utili tion of biological principles through the farming operation are included this list. Scientifically, the agronomic pects of sustainability, particularly tilizer and pesticide use, seem curren to be drawing the greatest confusion a contradiction.

Cultural practices

The use of commercial fertilizers, p ticularly nitrogen fertilizers, of proved crop varieties, and of ot cultural controls such as pesticides resulted in unparalleled increases in productivity of U.S. agriculture in

past four decades. Can we expect productivity increases to continue at the present rate? Are the curent projections of a 2 percent per year increase in crop yields realistic? These questions are critical to the debate over the need for increased food production to match the similarly unparalleled population increase in the world. Rather, might grain yields be stable or declining due to damage to the resource base and the loss of cultural controls such as pesticides (Lancelle, 1982)?

Biological cycles in cropped systems are not "tight" in the ecological sense, particularly for nitrogen (Keeney, 1986; Odum, 1989). Harvesting crops removes nutrients. While some soils have large natural reservoirs of potassium and phosphorus and some have received abundant supplies of these materials as fertilizers, all cropped soils eventually must run short of available potassium and phosphorus as they support profitable row crop production. This end result can be delayed by efficient cycling of nutrients from animal manures. However, nutrients ultimately must be supplied from external sources if economic yields are to be maintained (Hoeft and Nafziger, 1988; York, 1989).

Nitrogen management offers the greatest opportunity for fostering sustainability through the use of manures and legumes, but most calculations indicate that on a regional basis biological nitrogen fixation through use of field-grown legumes can never be sufficient to maintain grain yields unless major increases in the area devoted to legumes occur, an improbable development in most grain farming areas (Heichel and Barnes, 1984; Voss and Shrader, 1984; Keeney, 1986). Management systems are available, or are in the process of development, to increase greatly the efficiency of nitrogen utilization in row crops. Examples include: biotechnology to produce more efficient legumes and cereal grains, nitrogen credits for manure or legumes, better handling of animal wastes, application of nitrogen fertilizer close to the time of maximum crop use to avoid losses, and application of only the amounts of nitrogen needed to maximize nitrogen use efficiency while minimizing excess nitrate in the root zone and sampling the soil root zone for nitrate absorption in the late spring (Keeney, 1986; Blackmer et al., 1989; Stinner and House, 1989). Decision information systems also will be available soon to permit better management decisions (Keeney and Oberle, 1989). These are powerful systems models that enable one to estimate all sources of plant available nitrogen and provide an array of best management practices for supplemental fertilizer nitrogen application.

Pesticides

The issue of pesticide use on crops consumed directly by the public and on crops such as corn or soybeans that are processed or fed to animals is in reality two different issues. The first pertains directly to food safety and quality, while the second is related more to environmental, social, and economic concerns. Most farming systems involving tilled crops require use of pesticides. For example, over 97 percent of the row crops in Iowa are treated with herbicides. Replacement of herbicides with intensive management techniques such as ridge tillage, cultivation, crop sequences, and ecological techniques is the only viable approach to lessening the intensity of herbicide use (Stinner and House, 1989). This will require long-term research, and success will be achieved only slowly. The trend toward highly active compounds that are more environmentally benign is more likely to dominate the near-term herbicide shifts in sustainable agriculture (Beyer et al., 1986). These compounds are used at exceedingly low rates, thus greatly lessening their chance of environmental impact. However, they also are economic inputs, likely at comparable per acre costs to current herbicides. Thus, their use does not answer the profitability side of sustainable agriculture.

Another development is the use of crops genetically engineered to be resistant to some broad-spectrum herbicides such as glyphosate. These "herbicide seed" packages are nearly ready for marketing and offer the potential for greatly extending the current herbicide era. Their use has been questioned by many concerned with sustainability in agriculture (e.g., Keeney, 1989).

Soil erosion

Maintaining the depth and quality of the soil must be one of the prime goals of a sustainable agriculture. Control of soil erosion over the long term has proven difficult (Larson, 1981; Larson et al., 1982; Phipps and Crosson, 1986). Soil-conserving agricultural practices must be resilient to social, political, and economic changes, must be economical, must not involve tradeoffs that increase the rate of pollution of other environmental compartments, and must increase the diversity of the landscape and its biota. This adds up to most definitions of sustainability. All agricultural systems that are under consideration in respect to sustainability must at the outset consider soil conservation as their primary goal.

Crop rotations

Crop rotations, as opposed to monocultures, are considered a crucial component of soil and resource-conserving agricultural systems (NAS, 1989; Stinner and House, 1989). In much of the midwest, legumes, particularly alfalfa, are the primary alternate crops in a cropping sequence. Legumes have many recognized benefits, including lessening soil erosion and improving soil tilth, in addition to nitrogen fixation (Heichel and Barnes, 1984; Larson et al., 1982). Normally their profitable use requires that ruminant animals be included in the farm system. Ruminants, however, are not always a profitable venture. An alternate solution would be to develop additional markets for the legume, but there is no guarantee that these markets would provide a consistent profit.

Another approach is to develop alternative crops that can be adapted to the farming system and have dependable markets. Canola, the low-cholesterol oil crop that is gaining much attention, offers an example. Yet another possibility is the development of sources of sustainable biomass fuels, such as sorghums, that are ideal for ethanol

production.

Still, one must recognize that the cropping patterns within a region were developed over a long time and for good reasons. Much of the research in sustainable agriculture must be directed to improving current cropping systems.

Other resources

Scarcity of resources must be considered in designing the sustainable agriculture systems of the future. However, scarcity is a relative term. Water is scarce in the irrigated west, yet as a result of agricultural policies is relatively cheaper and more plentiful than water for irrigation in the rainfed regions. Petroleum-based fuels and natural gas for manufacture of nitrogen fertilizers are in limited supply, yet remain plentiful and relatively cheap because of current market forces. Over time, any one of these external inputs could become the factor limiting profitable agricultural production.

Animal husbandry

Most case studies of sustainable farms have emphasized systems that include animals (NAS, 1989). Animal agriculture has many advantages in sustainable farming systems. Animals provide nutrient cycling through manure, add value to farm products, provide an outlet for labor, and add diversity to farm operations (Stinner and House, 1989). Animal agriculture, however, also has its drawbacks. Improper handling of wastes will create water and air pollution problems, and the demand for animal products is limited and variable.

Other issues

The role of new technologies

Detractors of the current concerns of agriculture are quick to equate sustainability with a return to old-time farming techniques. This view, however, is not valid; we have never been able to turn back to old technologies, regardless of the sector under consideration (Stinner and House, 1989). Rather, new technologies will be required to help achieve agriculture sustainability. These technologies will range from simple to elegant and will come from equipment and electronic industries, agrichemical industries, the supply and consulting sector, the seed and animal breeding industries, and the biotechnology industries (Duvick, 1988; King et al., 1989; Stinner and House, 1989). Only time will tell how each of these technologies will affect agriculture. It is critical that research be supported to assure that they are incorporated into the resource-conserving agriculture systems of the future. The competitive position of U.S. agriculture in the global market demands that we progress with these technologies while maintaining a balance of social, ethical, and economic concerns relative to their introduction (Duvick, 1988).

Social issues

As indicated previously, sustainable agriculture encompasses numerous social issues. Many individuals have concerns about who controls the agricultural policy agenda. They feel that agricultural decisions are being removed from the individual and placed into the hands of the corporation by forces not under their control. This appears to be a long-term trend, yet it is difficult to document whether it is a major force in sustainable agriculture (Stinner and House, 1989).

Policies

Much has been written about the importance of federal policies on the agricultural systems that have evolved over the past several decades and their effect on increasing chemical use on commodity crops (Young, 1988; Daberkow and Reichelderfer, 1988; NAS, 1989). Major changes in agriculture will require changes in these policies. Changes in policy will come slowly and not without great debate; incentives may be required to hasten adoption of some alternative techniques (Daberkow and Reichelderfer, 1988; NAS, 1989).

Research

Some consider that sustainable ag culture might ultimately have more i fluence on the research agendas agricultural institutions than in day-t day farm operations (Ruttan, 198 There is little doubt that new conceptu models are developing (King et al., 198 Francis et al., 1989). These involve c ganization of holistic multi-disciplina teams and units (Odum, 1989; King al., 1989), participation of farmers a conservationists directly in the planni and conduct of the research, use of sy tems approaches to problem solvi (Keeney and Oberle, 1989; King et a 1989; Magette et al., 1989; Francis a Hildebrand, 1989; Stinner and Hous 1989), and development of research c pabilities beyond those found in the tr ditional agriculture colleges (Odu 1989; Hamilton, 1989).

Education

Educational needs in support of su tainable agriculture will require new a proaches other than those us previously (Odum, 1989; King et a 1989). This will involve teams of r searchers, extension specialists, farme and public citizens addressing specif issues. As expressed by King et a (1989), monocultural (one-way) co munication must be replaced by pol cultural communication environment Use of new technologies to improve c information transfer is already co monplace. In some situations, a retu to older methods such as demonstrati farms will also aid in information tra fer. It appears that farmer-to-farmer i formation exchange is superior transferring management techniqu (Francis et al., 1989; King et al., 198 Francis and Hildebrand, 1989). On-fa demonstrations must be conducted c operatively with the farmer organiz tions rather than in top-do institutions. Research inputs fro farmer-researcher cooperative effo will greatly increase the credibility of t information and should improve the ra of acceptance of sustainable agricultu technology.

Role of industry

Private industry at all levels is essential to a profitable and otherwise successful agriculture (Duvick, 1988). New product development requires the knowledge and capital available only from industry. Product marketing to the farmer level also is dependent on industry. Many sustainable practices will require consulting services and specialty products that can be supplied only by industry. I am confident that private industry will respond to the needs of agriculture by developing responsible, ecologically sound technologies.

Summary

There are many facets to the issue of agricultural sustainability. At present, the terminology is diffuse, leading to confusion and even hostility. Better definitions will develop around actual practices that evolve from research and educational programs now under way throughout the United States and elsewhere. Many other problems must be solved, including those of farm policy toward soil conservation, commodity prices, and flexibility of cropping systems. Progress over the long term will continue to require innovative thinking from our leaders in Washington and in the states. They need the research results just beginning to evolve from sustainable agriculture programs. It is critical that these programs be properly formulated. The research agendas being set now will influence the course of United States agriculture for a long time to come.

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ASCS offers assistance for alternative practices

A special regulation encouraging farmers in selected counties to adopt integrated pest management (IPM) and other low-input practices has been forwarded by the U.S. Agricultural Stabilization and Conservation Service (ASCS) to state ASCS offices. The regulation allows cost-share assistance for producers who develop crop management measures, including rotations, that "seek to minimize the amount of pesticides and nutrients used on the farm while maintaining farm income."

The new practice is aimed at reducing water pollution and protecting soils, says Jim Denley, Chief of Planning and Evaluation for the ASCS. For more information, contact state or county ASCS offices.

Low-input farming in practice: Putting a system together and making it work

Frederick Kirschenmann

Abstract. This paper analyzes some of the potential problems that can be anticipated in putting a sustainable system together on an operating farm, and proposes a few of the principle practices and management strategies required for making such systems work.

Key words: sustainable, low-input, environment, whole systems, conventional agriculture, crop rotation, sod regeneration

Introduction

A practicing farm is always different from a theoretical farm or a research farm. A theoretical farm represents the manner in which a farm might work or ideally should work. A research farm is one in which a piece of the farm is isolated and reduced to its simplest form and analyzed under controlled circumstances. A practicing farm may be shaped by ideals and guided by research, but it also includes the variables that are removed in research for the sake of reliable analysis, and in theoretical designs, for the sake of purity. In fact, real life always includes these variables. They are what E. F. Schumacher called "the messiness of growth." It is the presence of this "messiness" that makes it difficult to describe a practicing farm in a uniform manner (Schumacher, 1977).

This doesn't mean that we should refrain from speaking about farms in practice any more than it means that we should stop doing controlled research just because we can't apply it exactly. It probably does mean that we need to look at both kinds of data with a bit more humility than is usual.

At the outset, I will admit to a certain bias in favor of the word "sustainable" over the word "low-input." It seems to me that the word "low-input" emphasizes the wrong end of the input-output equation. Reducing certain inputs may increase short-term efficiencies on a practicing farm; if the right kind of inputs are reduced, it can decrease environmental degradation. But "low-input" lends itself too easily to the notion of "mining." Low-input suggests the notion of obtaining efficiencies through "getting by with less" rather than the notion of "restoring what we use in order to keep going." It is the latter notion, integral to the word "sustainable," that we need to attend to if we are going to solve some of the problems confronting agriculture. Simply cutting back on inputs will work, if at all, for only a brief period of time.

The agriculture community has not yet agreed on a precise definition for the word "sustainable," but that should not immobilize us. There are a number of working definitions that can serve us well while we wait for a universally acceptable definition to emerge. Wendell Berry (1984) has referred to sustainable agriculture as an agriculture that "depletes neither soil nor people." William Lockeretz (1988) has referred to it as an agriculture that "is capable of endur ing." And Canadian entomologist Stuar Hill (1987) has referred to it as a systen that is based, as much as possible, o "renewable resources and the recyclin of non-renewable resources and mini mally impacting the environment."

It should be noted that all of thes ways of referring to sustainable agricul ture are broad goal statements, not de scriptions of specific agricultura practices. Identifying those practice that are truly sustainable will come wit time, experience, and research.

Putting a system together

There are numerous approaches on could use to develop a practicing sus tainable system. The task is somewha similar to that of a medical doctor wh prescribes rules of conduct that enabl a patient to take better care of his body While such prescriptions involve a goo bit of science, they also involve ar Much depends on the personality of th patient, the personality of the docto how the two get on together, and hov skillful the doctor is in anticipating th patient's response to certain suggestions

Similarly, in putting a sustainable sys tem together for a practicing farm, muc depends on the farmer, much on th farm, much on how they get on togethe and much on how skillful the farmer i in anticipating how his farm will re spond to certain interventions.

Furthermore, there is probably mor than one starting point to use on th same farm with the same farmer. In a article that appeared in a recent issue o *Acres USA*, farmer Jim Bender (198 suggests, for example, that one shoul begin "one method at a time." Bende proposes that a farmer first become com fortable with some kind of rotation an diversified system before he attempts t

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reduce inputs. Although it can be done that way, in my experience a "whole systems" approach provides a more attractive starting point. A rotation that works with substantial amounts of nonrenewable inputs, for example, may not work without them.

In a whole systems approach, one would take a small piece of the whole farm and experimentally introduce a complete sustainable system on that acreage. This portion would incorporate all of the components of a potentially sustainable system. Based on the disclosures from this small part of the farm, one would then begin to apply the process to the rest of the farm. Drawing on our own on-farm experience, this second approach to getting started makes most sense.

Nevertheless, regardless of which starting point is selected, putting a sustainable system together always involves some common elements. There are common pitfalls to avoid, common practices to incorporate, and common problems to anticipate.

Pitfalls to avoid

The first pitfall to avoid in putting a sustainable system together is the notion that successful farming is a matter of following the right recipe.

Modern, conventional agriculture has taught us, in large part, to believe that progressive farming is a matter of following the right prescription. A successful farmer is one who utilizes soil tests to match up yield expectations with a standard set of inputs. He is one who reads labels carefully and applies standard recommendations for controlling weeds and insects and insuring proper soil fertility. The function of research, in this view, is to develop a model of an ideal farm that anyone with a bit of management cleverness can transplant to any farming operation.

Traditional farming, learned through apprenticeship, saw things differently. Decades were spent subtly teaching young farmers to read signs in nature, as well as in individual fields and animals, and to help them anticipate how certain interventions on the part of the farmer could affect this intricate natural system. There was a notion embedded in this learning process that led to understanding that no two fields and no two animals could be expected to respond to the husbandry of the farmer in exactly the same way.

Putting a successful sustainable system together will require that we rekindle this notion of cooperating with nature and discard our intrigue with "managing" the earth. This will take some time for, as E. F. Schumacher has pointed out, "standardized farming" has lost us the traditional knowledge of "how really to cooperate with the soil" (Schumacher, 1979).

It appears that a return to such principles may also be attractive to research scientists. At a conference on sustainable agriculture recently, some farmers described how they were controlling weeds by trying to understand how different weeds behaved in different environments. They had developed different strategies to respond to weeds in different environments. Afterward, a weed specialist from one of the land grant universities expressed his excitement in returning to this approach since it enabled him "to be a weed scientist again, instead of a label reader."

A second pitfall to avoid is the temptation to apply a potentially sustainable system immediately. Once a farmer has developed a system that works on a small portion of the farm, there is a strong temptation to transfer it, intact, to the whole farm. It is important to remember several key factors about sustainable systems that reveal the hazards of such wholesale transfer.

A sustainable system is, for the most part, a living system, not a set of mechanical connections. Living systems always behave differently under different circumstances, since they always try to adapt themselves to their environments. This means that even if the experimental acreage on one's own farm (let alone the sustainable system on a neighbor's farm) is very successful, one could be courting disaster by simply transferring it, intact, to the rest of the farm. When dealing with a living system, there simply is no substitute for using one's imagination to anticipate how a working model will adapt to a new field.

Furthermore, adopting a sustainable system is a process, not a technique. The same process one uses in developing the experimental acreage (selecting a starting point for a viable rotation, developing soil-conserving practices, introducing greater diversity, etc.) will need to be utilized on the rest of the farm. One cannot simply take the working system from the experimental acreage and move it on to the rest of the farm. It is a process of moving away from one management strategy toward another, not a matter of suddenly replacing one system with another.

It might also be well to recognize, in this context, that the task of developing a sustainable system is never done. Sustainable practices require constant attention to new ways of responding to the same problems, and a lifelong commitment to nurturing the system.

A third pitfall to avoid is the temptation to change techniques without changing systems. There is a tendency on the part of some farmers to construe new approaches to farming as simply adapting new techniques to what they have always done. That will not work in developing a sustainable system. Putting a sustainable system into practice involves a complex set of interconnections. A sustainable system of annual crop production, for example, will not work apart from an appropriate crop rotation. Attempting to switch to a sustainable system by withdrawing inputs without simultaneously developing a soil-building program and an appropriate crop rotation scheme would be disastrous.

Practices to incorporate

There are three management practices that are important to any sustainable farm. To remain sustainable, a farm needs to include an appropriate crop rotation scheme, a regenerative soil-conserving strategy, and a system of interactive diversification.

An appropriate crop rotation is essential to sustainable farming. Orchards, vineyards, and perennial polycultures aside, crop rotations are one of the most effective tools for insect, disease, and weed control, for maintaining acceptable

nitrogen and moisture levels in the soil, for improving soil tilth and structure, and for reducing soil erosion. For example, William Ball (1987), the Extension Agronomist at North Dakota State University, points out that over fifteen of the most common insects to attack crops grown in North Dakota can be partially or entirely controlled through crop rotations.

Developing an appropriate crop rotation scheme is one of the most challenging tasks in putting a sustainable system together for a practicing farm. Farmers should always develop a rotation plan with both the needs of the farm and the needs of a sustainable system in mind. Farm needs include such considerations as markets for the crops in the rotation, suitability to the soil type, moisture and climate conditions, equipment requirements, and on-farm feed and cash flow needs. Sustainability requires a crop rotation that accomplishes several objectives. First, the crop rotation should provide effective weed control. This can be accomplished through a combination of strategies including:

- Alternating between cold weather and hot weather plants.
- Including plants in the rotation that have allelopathic properties.
- Including crops like certain legumes or grasses that choke out weeds.
- Including crops that lend themselves well to mechanical weed control.
- Including plants with fibrous root systems that improve soil structure, thereby creating a more favorable environment for growing crops along with robbing weeds of the "space" to thrive in.
- Adjusting the rotation to attack target perennial weeds.
- Including a range of crops that help maintain a balance of nutrients in the soil, giving a competitive advantage to the growing crop.

Utilizing the strategies implicit in such a weed control scheme makes it possible to reduce weed competition so that it will not interfere with growing crops. Environmentally harmful herbicides made from non-renewable sources of energy can be eliminated from the practicing farmer's weed control arsenal.

A crop rotation should also provide effective insect and disease control. This can be accomplished by sufficiently isolating crops that are susceptible to the same insects and diseases. Increasing field isolation of similar crops in the rotation, as well as similar crops seeded in previous years, is crucial to this strategy.

A crop rotation should also improve soil conditions. Soil tilth and soil structure can be improved by including deep-rooted plants and plants with fibrous root systems in the rotation. These root systems can increase soil aggregate stability. Studies have shown that monocropping and black fallow practices pulverize soil. The smaller soil crumbs increase evaporability and compaction and cause soil to puddle and crust. Increasing soil aggregate stability, in turn, increases water infiltration and retention and thereby not only improves the soil's ability to sustain plants during drought conditions but helps to reduce both wind and water soil erosion. Furthermore, there is some evidence that improved soil structure increases biological activity in the soil and enables plants to utilize soil moisture and soil nutrients more readily (Goldstein, 1989).

Crop rotation can also contribute to the second practice that must be incorporated into a sustainable system: the development of a regenerative soil-conserving strategy. Not only can crop rotations maintain nitrogen levels by including legumes in the rotation, but other soil nutrients and trace elements may be released or enhanced through the inclusion of certain crops in the rotation. For example, since buckwheat absorbs phosphorus very efficiently, it can help to release fixed soil phosphorus by building up a store of organic phosphorus. Combining buckwheat with a legume provides a further benefit in that the deep-rooted legume can help to bring up phosphorus from deeper soil, something buckwheat cannot accomplish with its shallow roots.

Green manure crops are another important ingredient in any regenerative soil-conserving strategy. Green manure adds organic matter to the soil, assists in dissolving insoluble nutrients, brings up nutrients from the subsoil, and improves the soil's water-holding capacity. These contributions to soil fertility and tilth help to sustain a soil's product capacity and reduce erosion.

Livestock manure is another key gredient to a regenerative soil-conse ing system. While handling costs ma livestock manure less efficient th green manure, it has many other adv tages that make it an extremely desira soil amendment (Anderson, 198 Composting manure increases its val The high temperature in the composti process destroys most weed seeds. It duces the raw material to about o fourth its original volume, decreasi the cost of spreading. Composting s bilizes the nutrients, reducing the risk pollution. Composting provides a m stable humus which improves soil a ation, water infiltration, and water-ho ing capacity (Koepf, 1989).

Additionally, a good regenerative s conserving system needs to include t ditional soil conservation techniq such as wind barriers, grassed wat ways, strip cropping, conserving tilla and cover crops.

The third practice that needs to incorporated into a sustainable farm an interactive diversification syste The requirements of a good crop ro tion and soil-building strategy, no above, have already established the cessity for diversity. These diverse co ponents should form an interact system that takes advantage of symbio relationships. Such interaction is only important to the farm's efficie but to its survivability.

In putting together a crop and li stock system, for example, attenti should be given to maximizing the tential for mutual support inherent the two components. Crop residue is excellent feed source for livestock. Li stock manure can be composted and turned to the fields as a fertility sou for crop production. Various crop a livestock components can be integra to minimize the effects of weather- lated adversities. Crops damaged by timely rains can be used as livest feed, thus mitigating the loss. When c crops are destroyed by hail, they can s be grazed to recoup some of the l Furthermore, a hail-devastated farm s has the cash livestock receipts to back on. Such strategies can be cru

to a farm's survival.

Problems to anticipate

In any new venture, it is important to anticipate problems. The first difficulty faced in putting together a sustainable system is the problem of withdrawal. When shifting from a production system that relies principally on non-renewable inputs for fertility and pest control to a system that relies on other technologies, one cannot withdraw the inputs all at once. Until pest cycles are broken with a good crop rotation, it may be necessary to continue using pesticides. Until soil is restored through regenerative practices, it might be necessary to continue using synthetic fertilizers.

The need for additional facilities is also a pressure in changing systems. A diverse crop rotation requires additional storage space to accommodate the additional crop varieties. If livestock are added to the farm, facilities for housing and handling them will be required.

A third problem to anticipate is that of matching equipment needs with the new management practices. Livestock manure will require equipment for composting and spreading. Green manure will require equipment to properly incorporate vegetation without leaving soil unprotected. Soil-conserving tillage and mechanical weed control will require equipment that kills weeds and prepares seedbeds without burying all of the trash. Blade plows, rodweeders, harrows, no-till seeders, and rotary hoes may need to be added to equipment lines.

The need for additional labor will also demand attention in a transition. It is generally conceded that sustainable farms may be more labor intensive. That makes it necessary to reassess the farm's labor needs and build them into the farm's economic profile.

Finally, it should be anticipated that, until the weed control strategies outlined above are fully implemented, controlling weeds without herbicides may prove difficult. Effective weed control continues to be one of the more challenging problems facing growers who eliminate their herbicide input, especially when a farm has had a long history of monocropping.

Making it work

If a sustainable system is put together using the strategies outlined above, then making it work is primarily a matter of exercising practical wisdom and craftsmanship. There is no standard recipe for organizing or managing a farm to make this system work, but some clues may be helpful to consider.

One of the classical architects of management strategies for making things work was Niccolo Machiavelli, a 16th century Italian statesman. It may seem strange to call on Machiavelli for clues on how to make a sustainable farm work, especially since he was an advocate of unbridled power in which the ends always justify the means. Sustainable agriculture is more tuned to sentiments that recognize the need to submit to the power of nature and to employ tools of gentle adjustment. Nevertheless, even though we may disagree with Machiavelli's political philosophy, he provides some pearls of wisdom on how to make things work.

Machiavelli notes, for example, that a wise king always lives in the province he rules, since that is the only way to recognize problems in a timely manner.

"...it happening with this as with those hectic fevers, as doctors say, which at their beginning are easy to cure but difficult to recognize, but in course of time, when they have not at first been recognized and treated, become easy to recognize and difficult to cure..." (Machiavelli; tr. Ricci, 1935, p. 39.)

Consequently, when for lack of close, personal knowledge, evils "...are allowed to grow so that everyone can recognize them there is no longer any remedy to be found." (Machiavelli, p. 39).

That might well be a quote sustainable farmers should hang on their kitchen walls. Recognizing problems in a timely manner through close, personal observations is crucial to making a sustainable system work. If one allows a weed problem to grow so that everyone in the neighborhood can recognize it, it is probably too late to find a remedy. Weed and insect problems can only be solved without pesticides by utilizing preventive management strategies. Consequently, if a farmer wants to reduce or eliminate reliance on fertilizers and pesticides, it will be necessary to walk the fields, scrutinize weed problems, carefully analyze growing plants, and give close attention to the entire soil profile. That means the farmer has to live on the farm. Absentee sustainable farming will not work. Sustainable practices probably also will not work on farms too large to be personally managed by the owner/operator.

Second, Machiavelli suggests that enterprises need to develop in accordance with natural growth patterns.

"States quickly founded, like all other things of rapid beginnings and growth, can't have deep roots..., so that the first storm destroys them." (Machiavelli, p. 52).

To a degree, sustainable systems have to be allowed to develop at their own pace. It takes time for soil to regenerate itself. It takes time to discover the right combination of sustainable strategies for a particular farm. It takes time to break insect, weed, and disease cycles.

On the other hand, Machiavelli recognized the importance of a certain degree of impetuousness. He suggested that, if one were to wait until all arrangements were made and everything was settled, one would never succeed. "It is better to be impetuous than cautious." (Machiavelli, p. 123). While it is important to allow a sustainable system to develop by its own principles of growth, it is also important not to be too cautious. One can always find good reasons to delay. Without a certain degree of impetuousness, one would probably never start.

Finally, Machiavelli recognizes the importance of embracing ambiguity:

"Let no state believe that it can always follow a safe policy, rather let it think that all are doubtful. This is found in the nature of things; that one never tries to avoid one difficulty without running into another. But prudence consists in being able to know the nature of the difficulties and taking the least harmful as good." (Machiavelli, p. 112).

Every farmer who has put a sustainable system together and tried to make it work can probably relate to that statement. Often one does try to avoid one problem only to run into another. Clearly there are no absolute right or

wrong answers. And most farmers recognize the need to develop an ability to judge among the lesser of several difficulties. In sustainable practices one soon discovers, for example, that all weeds are not bad and that practices that appear good in the short term turn out to be destructive in the long term.

Beyond Machiavelli's clues, there are perhaps two other items of import in making a sustainable farm system work. A farmer contemplating putting this kind of system together and making it work needs to make a firm commitment to the philosophy and practice of sustainable agriculture. Cooperating with a living system always brings surprises and disappointments; and, without a steady commitment, a farmer might easily become disenchanted and abandon the project altogether.

Luck, imagination, and a sense of humor play an uncomfortably large role in making sustainable farming systems work. On our own farm, some of the most successful practices we are using were discovered largely through luck. We are also continually reminded of the importance of using our imaginations as we try to cooperate with nature's ecosystems. Refusing to become locked in to standard ways of doing things and continually imagining new possibilities is crucial. A sense of humor is indispensable. Farming always has had an enormous potential for exposing one's capacity for stupidity. Sustainable farming probably increases that potential since it requires more thought, imagination, and management. Without a sufficient sense of humor to laugh at himself, a farmer probably would become disillusioned.

Finally, being part of a support group is important. Gathering and sharing information with other farmers who are trying to make similar systems work on their own farms is extremely valuable. Recently, such sustainable agriculture groups have also begun to interact with university researchers; and the results appear to be very positive for everyone involved. In any case, the information and imagination generated by such groups has been an indispensable source of inspiration to farmers involved in sustainable agriculture practices.

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Too much nitrogen cuts vitamin C in plants

Excessive nitrogen fertilizer can cut vitamin C in some leafy green vegetables by as much as 50 percent, says soil scientist Sharon B. Hornick of the USDA ARS Laboratory at Beltsville, Maryland. Too much nitrogen is bad, regardless of whether it was synthetic or organic, Hornick concluded. She grew swiss chard and green beans in potted soil in a greenhouse, applying manures, sewage sludge compost, or inorganic fertilizers. Hornick eliminated the soil as a contributing factor by tests of plants grown hydroponically, without soil.

The research was reported in the July 1989 issue of *Agricultural Research*, a publication of the USDA Agricultural Research Service, Room 316, Building 005, Beltsville, MD 20705.

Northeast farmers network formed

As interest in lower- and no-chemical approaches to farming has grown, organic growers are finding themselves in the unaccustomed role of farm advisors to their conventional peers. Responding to the information demand in the northeast, the Natural Organic Farmers Association (NOFA) has joined the Maine Organic Farmers and Gardeners Association and Cooperative Extension in seven states to create the Northeast Organic and Sustainable Farmers Network. A $115,000 two-year grant from LISA funds part of the program, with remaining funds coming from NOFA and Cornell Cooperative Extension.

In 1989 the Network held a series of six farm field days in New York state, targeting vegetable, apple, small grain, and hay farms plus several on-farm composting sites. Over 40 farmers and extension agents attended each event. A brief evaluation showed that many of the farmers were considering methods from IPM to reducing herbicides as a result of exposure to the ideas. For 1990 a network of "master organic and sustainable farmers" will be selected in each participating state to hold field days. The project will also produce a manual of organic and sustainable farming methods for the northeast.

For more information on the Network, contact Judy Green, Farming Alternatives Project, 443 Warren Hall, Cornell University, Ithaca, NY 14853, (607) 255-9832.

Crop rotation efficiencies and biological diversity in farming systems

David F. Bezdicek and David Granatstein

Abstract. *The positive role of biological diversity in enhancing agricultural sustainability is presented in the context of crop rotation. Once common in virtually all farming systems, crop rotations have been simplified or eliminated during the past two decades from farming systems in most industrialized countries. Specialization, production intensification, government commodity programs, and the resulting short-term economic decisions have all had an influence in reducing crop rotation and diversity. Economic and environmental concerns have raised the question of agricultural sustainability in the public arena. We discuss here the role of diversity and crop rotation in relation to the sustainability issue, including matters of agronomic, economic, and environmental benefits, as well as increased efficiency in the use of fossil fuels. Constraints and future directions in the use of crop rotation in modern agriculture are described.*

Key words: monoculture, genetic uniformity, plant epidemics, genetic engineering, transgenic plants, production inputs, sustainability

Introduction

Farmer-author Wendell Berry (1981) describes "agricultural solutions to agricultural problems" as those measures that tend to "create more solutions, not more problems." In contrast, he believes that "industrial solutions" to farming often "create more problems than they solve." Crop rotation, one example of an "agricultural solution," is discussed in this paper.

Crop rotations in association with animal enterprises were probably practiced in agriculture from prehistoric times until the period when synthetic fertilizers began to replace nutrients depleted from the soil, and mechanization and pesticides were used more extensively to control insects, weeds, and pathogens. The internal combustion engine replaced the need for draft animals, and this in turn reduced the need for forage legumes and grasses. Through plant breeding of shorter and stiffer-stemmed varieties, as well as through increased use of fertilizers and pesticides, and through changes in crop management, cereal yields increased substantially from the 1940's to the present.

Modern agriculture is energy intensive and relies heavily on petroleum-based external inputs of chemicals and fertilizers. In the future, however, these inputs may be limited by environmental and food quality concerns, as well as by reduced availability and higher prices. More emphasis on biological control, increased diversity of genetic stocks, and longer crop rotations may reduce the need for some of the current inputs.

Diversity in cropping systems

Diversity in cropping systems is related to the genetic diversity of the crops, to the mix of crops planted in space or time, and to biological diversity in the soil. Environmental factors such as temperature and moisture influence diversity by limiting the range of types of crops that can be grown and the kinds of soil flora and fauna that result.

In agricultural systems, a greater complexity of the soil microbial community is thought to lead to greater yield stability (Cook and Baker, 1983). This complexity can decrease the rate of invasion by foreign organisms, especially pathogens. On the other hand, agroecosystems involving monoculture or short crop rotations and containing plants with a narrow genetic base are less diverse and consequently more vulnerable to invasion by insects, disease microorganisms, nematodes, and weeds (National Research Council, 1972; 1989). In large acreages of single crops and varieties, epidemics such as those associated with rust fungi and other diseases are favored (Baker and Cook, 1974). A similar situation was involved in the disastrous potato blight epidemic in Ireland, caused by the introduced fungus *Phytophthora infestans* on a relatively susceptible and genetically uniform potato crop. A more recent example in the U.S. was seen in the southern corn leaf blight epidemic (*Helminthosporum maydis*) in the 1970's. Most of the corn hybrids involved carried a factor for male sterility which also conditioned susceptibility to the disease.

Traditional plant breeding has contributed tremendously to disease and pest control and can be regarded as responsible for an average increase in crop yield of 1 percent per year over the past 50 years (Witt, 1982). Yield increases of 100 percent or more have been reported for most major commodities (Fehr, 1984). However, there are concerns about the relative genetic uniformity in many of our corn varieties (Smith, 1988)

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and about the potential of future varieties to respond with resistance to diseases and environmental stresses if genes are not maintained from diverse sources in germplasm banks (Duvick, 1986).

Biotechnology may aid in the process of increasing genetic diversity through mapping of plant genes by restriction fragment length polymorphisms (RFLP) and may decrease the time needed to develop varieties through tissue culture. Development of plants resistant to diseases, insects, viruses, and herbicides through genetic engineering is well underway (Schell et al., 1989; Goodman et al., 1987), as is the release of transgenic microorganisms (Lindow et al., 1988). However, there is concern that transgenic plants and microorganisms may not improve genetic diversity, for example, in view of the wide interest in introducing genes into plants for resistance to herbicides (glyphosate) and for expression of the delta endotoxin from *Bacillus thuringiensis*. These concerns and the fate of released transgenic plants and microorganisms are of considerable interest (Gould, 1988; Tiedje et al., 1989).

Loss of biodiversity of our plant, animal, and insect species is of concern especially as a result of deforestation of our tropical rain forests (Wilson, 1988). Little is known, however, about the potential loss of diversity in the microbial and soil insect populations resulting from serious soil erosion and disturbance and intensive chemical agriculture. Diversity can potentially be increased by the use of crop rotation, as in the case of corn production in the Midwest. Continuous monocropping of corn offers a farmer some clear benefits - a single line of machinery, specialization of management skills, and maximum returns from federal commodity programs. The list of problems associated with monoculture, however, is long - high soil erosion potential, depletion of soil organic matter, reliance on high rates of nitrogen fertilizer, increasing levels of insect pests, uneven demands on labor and equipment, and lower maximum yield potential. In time, the farm under such systems becomes increasingly dependent upon external production inputs and thus increasingly vulnerable to disruption of supply or to price escalation.

Models for sustainable cropping systems

Many social factors affect the movement of agriculture towards long-term sustainability. Changing perceptions about farming as a "business" or "industry," the meaning of "efficiency," and the role of soil in agriculture have helped to shape the current structure of agriculture in the U.S.

On a recent tour of agriculture in the Soviet Union, Rodale (1988) identified two contrasting goals in agricultural production. The "farm goal" favors production with the least amount of off-farm derived raw materials, thereby maximizing the use of "free inputs" such as soil, air, water, and sunshine. The "factory goal" attempts to maximize the input of raw materials and the flow of products out of the system. Rodale attributes much of the failure of Soviet agriculture to the pursuit of the factory goal.

One component of sustainability is an increased reliance on renewable resources, such as biologically fixed N, and on inputs internal to the farm, such as knowledge skills, on-farm labor, and farmer-based management decisions. External physical inputs such as fossil fuel based fertilizers and pesticides are not necessarily "bad," except to the extent that they rely on non-renewable resources. Over-reliance on them can be expensive and makes agriculture vulnerable to a supply disruption or major price escalation. Most farms have a mix of external and internal inputs. While specialization is a driving force in the general economy, diversity enhances the productivity and efficiency of many biological systems. For example, diverse cropping systems and crop-livestock combinations allow farmers to effectively utilize forages and crop residues and spread the risks of production over time and space (Kirschenmann, 1988).

Components of a more diverse cropping system

The role of soil quality and productivity

Modern technological advances in ag
riculture have lessened the perceived im
portance of the soil resource i
maintaining a productive agriculture
Quality criteria have been defined fo
grain, fruit, and vegetables, but few cri
teria are available to evaluate "soil qual
ity." One component of soil quality i
soil fertility, which is defined by the Soi
Science Society of America as the abilit
of the soil to supply nutrients to plant
and includes factors such as soil pH
available nutrients, etc. (SSSA, 1984)
Adjustments to overcome fertility prob
lems are made with applications of fer
tilizer nutrients or soil amendments
based on soil test recommendations. Soi
quality is dependent upon good soil fer
tility but also includes a number of pro
ductivity factors not easily or routinel
determined from a soil test sent to
laboratory.

One important soil quality factor i
soil structure, which is essential for plan
health and for efficient utilization o
plant nutrients and soil water. Soil struc
ture determines the pore size distribu
tion of soil, which is related to the size
shape, and stability of aggregates (Lync
and Bragg, 1985). Larger water-stabl
aggregates in the 1 to 10 mm range allo
soil fauna more habitable space, reduc
bulk density, promote soil aeration, in
crease infiltration, and provide space fo
plant roots to grow (Oades, 1984)
Earthworm activity leads to the for
mation of more water-stable aggregate
(Huang, 1979). A greater proportion o
large soil aggregates decreases evapo
rative losses through the reduction i
capillary rise (Doyarenko, 1924). On
farm observation suggests that surfac
soils with good aggregation achieve
through crop rotation can increas
drought resistance (Goldstein, 198
Kirschenmann, 1989).

Plant roots promote soil aggregatio
through the stimulation of microorgan
isms that produce polysaccharides an
other carbohydrates which then serve t
bind soil particles together. Both ferti
izers and manures stimulate plan
growth, which increases root productio
in most plant species. However, Krame

and Weaver (1936) have shown that grasses build up soil structure and aggregation quicker than other plants because of the large quantities of fine roots they produce. Although it may not be fair to compare perennials and annuals, it is significant that native grasses produced greater root masses than brome grass, and substantially more than cereals (Table 1). The duration of grass within a crop rotation sequence can increase both the yield of wheat and the infiltration of water into the soil (Table 2). The frequency of grass in the rotation also can increase the proportion of water-stable aggregates as shown in Australia by Russell and Williams (1982) (Figure 1). Fallow in the rotation can reduce potential aggregation by the reduced input of plant residue and mechanical tillage.

A systematic attempt has not been made to set criteria for evaluating soil quality, although some criteria were developed by the Soil Conservation Service in the 1960's (SCS, 1974). A given crop rotation and the associated tillage and fertility practices were assigned numerical ratings (positive and negative) to estimate whether a specific cropping system was improving, maintaining, or deteriorating the soil over time. The net value did not rate the erosion effectiveness for the system, only the impact on the "desirable soil condition."

Soil tilth, a qualitative term usually attributed to denote how well a soil "works" when tilled, is familiar to all farmers and should not be dismissed by scientists because of the lack of a quantitative test. Perhaps the terms soil quality and soil tilth suffer from the same problem in that measurements are not easily quantifiable.

Soil nutrients

In modern agriculture, long-term soil fertility and crop productivity are likely to be maintained by a combination of fertilizers and pesticide inputs, proper crop rotation, and management strategies to control pests, weeds, and diseases. Without closed nutrient cycles, the export of crops from a farm will require the continued importation of nutrients, especially P and K (Follett et al.,

Table 1. Dry weight of living underground plant parts for grasses, legumes and cereals.

Crop	Upland	
	-kg/ha-	%
Perennial crops		
Big bluestem	9,184	100
Slough grass	14,829	161
Brome grass	4,397	48
Alfalfa	3,917	43
Annual crops		
Winter wheat	1,499	16
Oats	979	11
Corn	1,299	14

Adapted from: Kramer and Weaver, 1936.

Table 2. Effect of brome and wheatgrass on wheat yield and infiltration.

Years of Grass	Wheat Yield	Infiltration after Water on Surface for:	
		10 min	1 hr
	Mg/ha	--- cm/hr ---	
0	2.8	3.8	1.5
2	3.3	4.1	2.0
6	3.4	4.8	2.5

Nebraska data of Mazurak and Ramig, 1963.

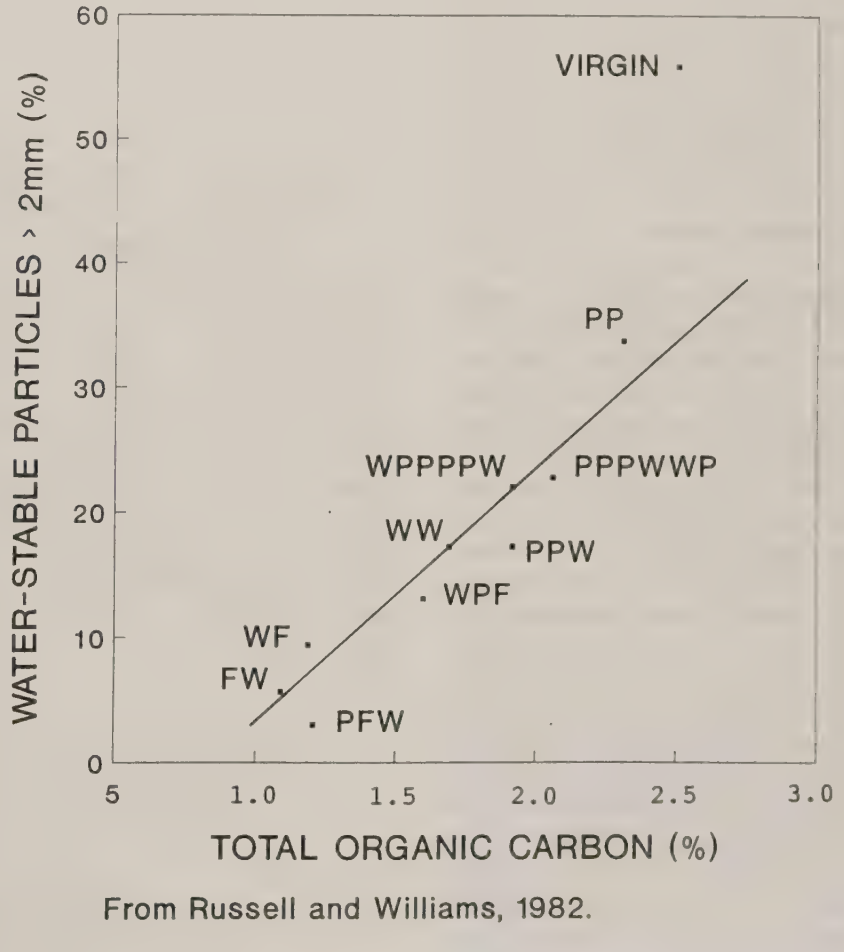

Figure 1. Influence of crop rotation and soil organic carbon on water soluble aggregation. F=fallow; W=wheat; P=pasture (Russell and Williams, 1982).

1987).

Opportunities exist for increasing on-farm nitrogen contributions from legumes in rotation and for better utilizing native soil nutrients by including deep-rooted crops that can bring subsoil nutrients to the surface. Long-term studies on the Morrow plots at the University of Illinois clearly show higher levels of soil organic matter and soil N when cropped with a rotation of corn-oats-clover than continuous corn (Stevenson, 1982). Although losses of N occur in all cropping systems, they appear to be lower in forage legume-based rotations than in rotations utilizing inorganic N in long-term studies on the Sanborn plots in Missouri (Smith, 1942). Soil organic matter in long-term plots in eastern Oregon was the highest when manure and pea vines were added in a wheat-fallow rotation and lowest when the residue was fall burned (Figure 2) (Rasmussen et al., 1989). Recovery of applied N in wheat was about the same for all sources but decreased with rate of application (Rasmussen et al., 1989). The economics of various cropping systems will depend in part on prices and farm commodity programs.

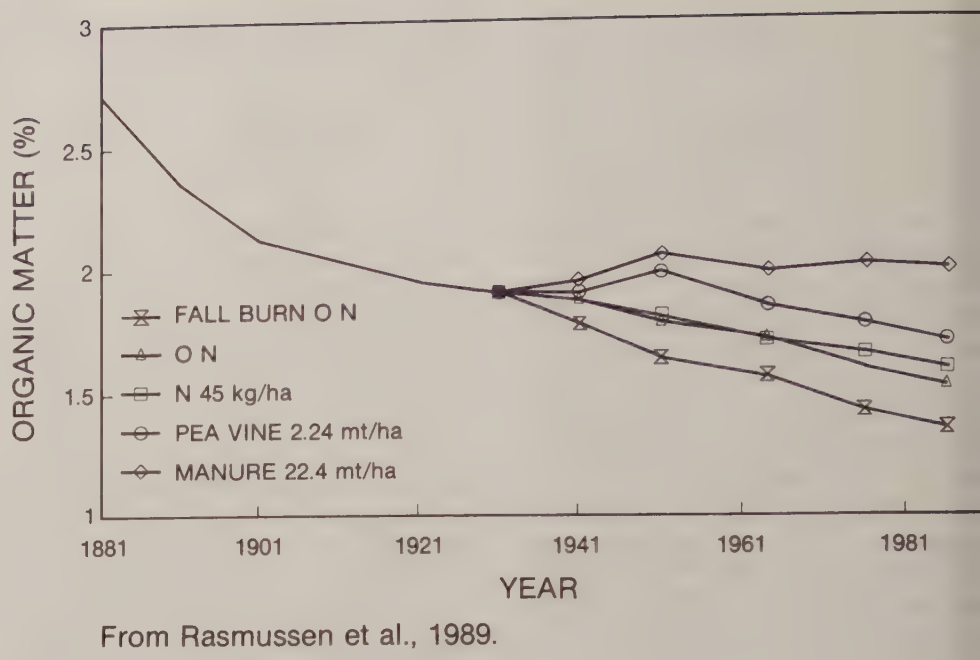

Figure 2. Changes in soil organic matter in the top 30 cm of soil from 1881 to 1986, including residue management effects from 1931 to 1986 in a wheat-fallow rotation at Pendleton, OR. (Rasmussen et al., 1989).

The rotation effect

Wheat, corn, and soybeans exhibit higher yield potentials when grown in rotation than in continuous cropping (Cook, 1988; Pierce and Rice, 1988). This phenomenon known as the "rotation effect" can be defined as the effect on crop yield in moving away from continuous culture. The effect is usually positive and is attributed to numerous factors, some of which include a reduction in diseases, insects, nematodes, and weeds, improved soil physical conditions, and favorable effects of N from previous legumes. Pierce and Rice (1988) have further defined a number of theoretical models showing the yield response to applied N under monoculture (M) and after a rotated (R) legume crop (Figure 3). Situation A shows that a crop rotation does not respond to added N, whereas added N in monoculture can increase yield equal to that obtained in rotation. In situation B, yield in monoculture never reaches the yield in ro-

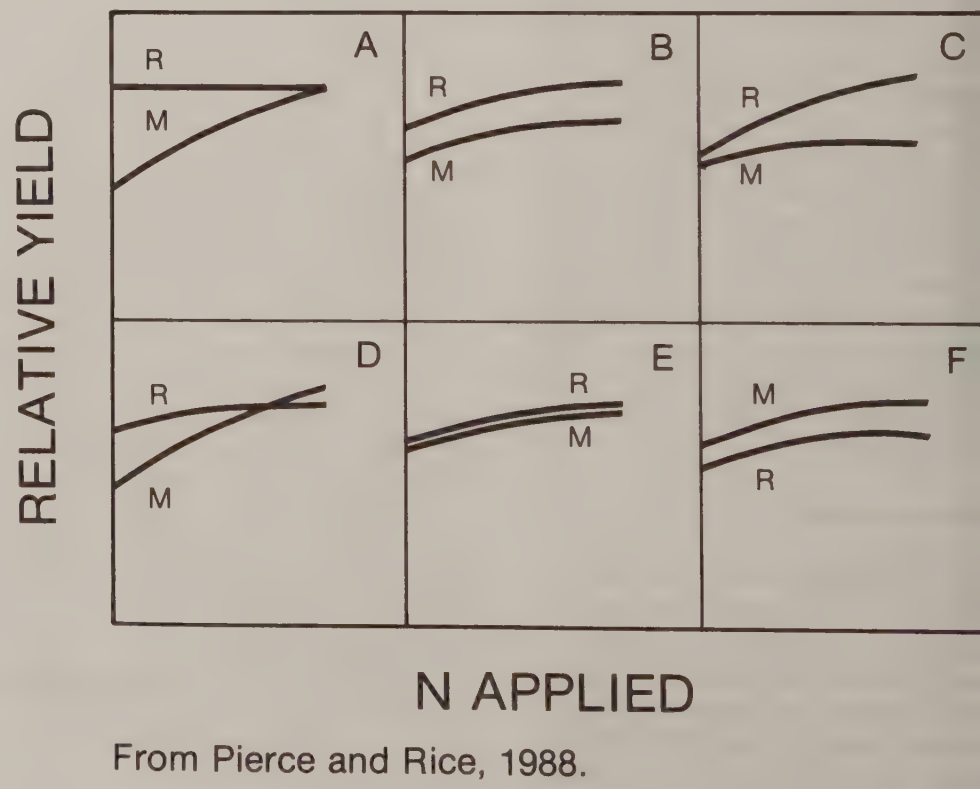

Figure 3. Models of six types of crop responses to applied N comparing rotation (R) to monoculture (M (Pierce and Rice, 1988).

tation regardless of added N. The latter scenario has been shown by Randall (1988) in southern Minnesota where corn yield in monoculture never approaches the yield in rotation (Figure 4). Furthermore, corn yield following either wheat or soybean was similar.

Nitrogen inputs from legumes in rotation

The amount of N returned to the soil from grain legumes and forage legumes is dependent upon the total N fixed and the proportion of total plant N removed at harvest. Grain legumes generally export more N in the seed at harvest than that added by N_2 fixation (Eaglesham, 1982; Heichel, 1985). Under Minnesota conditions, Heichel and Barnes (1984) estimate that soybeans can export a net 80 kg N/ha when 40 percent of their N is derived from N_2 fixation. However, positive budgets have been reported for cowpeas by Eaglesham (1982), for irrigated soybeans in Washington state under low levels of soil N (Bezdicek et al., 1978), and for soybeans in the southeast (Thurlow and Hiltbold, 1985; Hunt et al., 1985).

Forage legumes, on the other hand, usually result in higher quantities of N fixed and usually return larger quantities to the soil, depending on how much is removed for hay (Heichel and Barnes, 1984) and how often the legumes are included in the rotation (Baldock et al., 1981). Table 3 shows an equal sorghum yield response from four forage legumes and fertilizer N in the southeast U.S. Other instances show that the incorporation of forage legumes does not meet the N needs of a following crop (Fry et al., 1988).

When corn follows a grain legume crop such as soybeans, the soybeans have been reported to supply about 1 kg of N for every kg of seed harvested (Voss and Schrader, 1979; Heichel and Barnes, 1984). In view of the net exportation of N when Midwest soybeans are harvested (Ham, 1978; Heichel and Barnes, 1984), the apparent "N contribution" must be attributed to factors other than to N, such as the rotation effect. Data by Randall (1988) in Figure 4 show nearly the same rotational effect for soybeans and

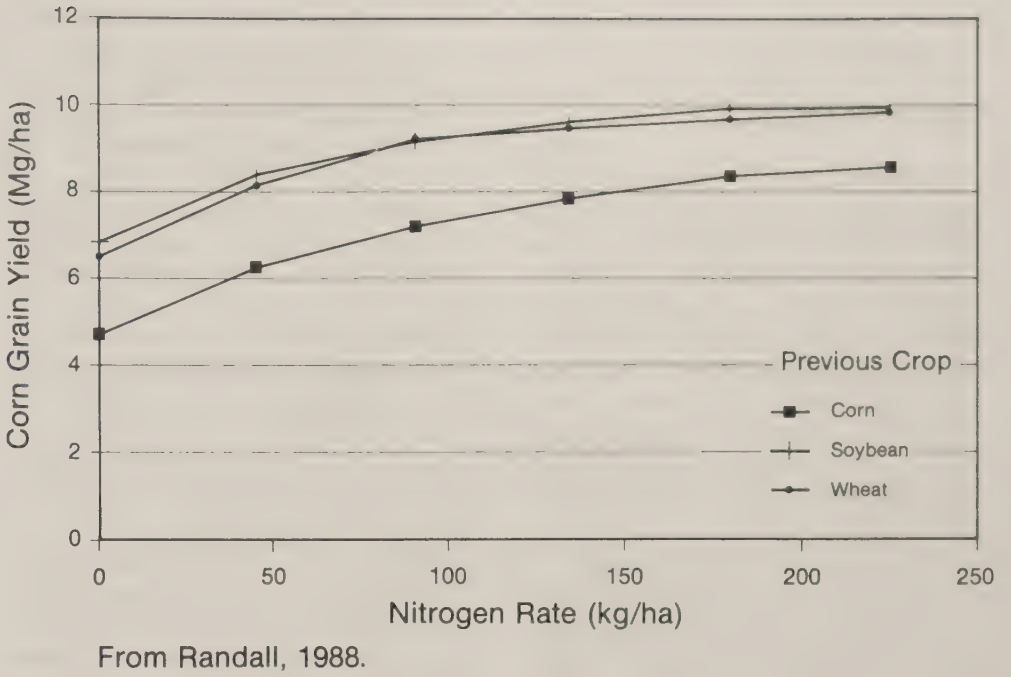

Figure 4. Effect of crop rotation on corn yields at different nitrogen fertilizer rates in 12-year study in Minnesota. (Randall, 1988).

wheat. Of course, if the entire seed legume crop were turned under as a green manure, a positive N balance would result.

Another term used to assess the N value of a legume is "fertilizer N replacement value" (or N equivalent), which is the amount of inorganic N required to produce a crop following a non-legume that is equivalent to the yield produced by a crop following a legume that was incorporated (Hesterman, 1988). This approach assumes that non-legume yield is due solely to the legume N contribution and that fertilizer N and legume N are equally available (Hesterman et al., 1987). This is often not the case and, therefore, the rotation effect may contribute to the N replacement value. Replacement N values of 176 kg N/ha (Boawn et al., 1963) and 180 kg N/ha (Voss and Schrader, 1979) for alfalfa have been reported. While the term N replacement value may be difficult to quantify scientifically, it is of practical use to farmers for judging the substitution value of legumes for fertilizer N. Baldock et al. (1981) and Hesterman et al. (1987) have attempted to partition out the rotation effect to evaluate the contribution due to N. However, it is likely that the term "rotation

Table 3. Grain sorghum yield in Georgia in response to forage legumes and fertilizer N.

Winter Cover	Fertilizer N (kg/ha)	
	0	112
	--Yield (Mg/ha)--	
Fallow	2.9 a	3.9 b
Hairy vetch	4.0 a	3.8 a
Common vetch	3.7 a	3.9 a
Crimson clover	3.9 a	4.2 a
Subterranean clover	3.9 a	3.9 a

Hargrove, W. L., (1986). Adapted from Fry et al. (1988).
Values with different letters across columns are significant at p=.05.

effect" will continue to remain somewhat undefined.

Nitrogen efficiency

Another useful but sometimes misused term is "N uptake efficiency" (NUE), which is often defined as the plant uptake of N per unit of N added. By this definition, one would expect NUE from legumes (NUE_L) to be lower than NUE from fertilizer (NUE_F), since more of the legume N is not immediately available, and thus a greater portion of legume N may remain in the soil organic matter and biomass pools. Studies using ^{15}N-labelled legume residue show that 10 to 30 percent of the N is recovered by a following crop (Ladd and Amato, 1986; Harris and Hesterman, 1987), compared to recoveries from fertilizer N of 30 to 70 percent (Stanford, 1973). Hesterman et al. (1987), using ^{15}N-depleted ammonium sulfate on corn following alfalfa, soybeans, and fallow in Minnesota reported an average NUE_L value of 43 percent for alfalfa and soybean as compared to a NUE_F value of 51 percent from ammonium sulfate fertilizer. Corn derived an average 36 percent of its N from alfalfa and 12 percent from soybean.

The efficiency of applied N sources can also be evaluated over a longer time period to develop a total N budget of inputs (N fertilizer, N_2 fixation, or N deposition), outputs (harvest, leaching, volatilization, denitrification), and total soil N. When comparing NUE between legume and fertilizer sources, it is necessary to estimate changes in N pool sizes (e.g., organic matter, microbial biomass, inorganic N, etc.) (Meisinger, 1984). For example, a greater proportion of N added from legumes (as opposed to fertilizer N) that is not taken up by the plant may reside in the organic N and microbial biomass pools, since carbon is added along with the legume N. Consequently, the N mineralization potential would probably increase. Potential losses of N through leaching and denitrification are probably not the same for legume and fertilizer N. Therefore, a NUE term should include, in addition to plant uptake of N, changes in soil N that are likely to take place over time when different rotations are compared, especially when substituting legumes in part or in whole for fertilizer N.

Diseases, pests, and weeds

Disruption of diseases, pests, and weed cycles is considered to play a major role in the rotation effect. The concept that a "healthy soil" makes for a "healthy plant" has been postulated for many years (Howard, 1956), but has not been investigated in depth. Healthy plants utilize nutrients and water from the soil more efficiently, other factors being equal (Cook, 1988). Some farmers contend that healthy plants are more resistant to insects, thus reducing the need for insecticides. Preliminary results at Washington State University indicated that wheat plants in rotation with forage legumes were more competitive with weeds than when preceded by barley in a cereal rotation (W. Goldstein, personal communication).

Studies by R. J. Cook of USDA-ARS at Pullman, Washington, have emphasized the importance of plant root health. Soil fumigation has been used as a research tool to reveal the "full" yield potential of wheat. A large fumigation response indicates yield suppression by soil pathogens, pests, and weeds under field conditions and is typically highest (up to 70 percent) in continuous wheat, 13 to 36 percent in a two-year rotation (wheat 50 percent of the time), and from 3 to 12 percent in a three-year rotation (Cook et al., 1987). By lengthening the time between wheat crops, one Washington state grower reported harvesting more total wheat when cropping only one-third of his land to winter wheat each year (3-year rotation) compared t cropping half his land to wheat (2-yea rotation) (Cook, 1988). A crop of pea and sudangrass incorporated before po tatoes under irrigation in Washingto state had an effect on yields similar t that of fumigation under continuous po tatoes, indicating the potential of certai crops to reduce the level of soil-born pathogens (Cook, 1984) (Table 4).

It should be emphasized that fumi gation is a research tool and not a prac tical approach for most crops Fumigation drastically reduces soil mi crobial populations and in particular th soil nitrifiers (Rovira, 1976). Winte wheat seed yield decreases of 42 percen were reported from fumigation b methyl bromide in Oklahoma (Trent e al., 1989). Reduction in the colonizatio of vesicular-arbuscular mycorrhizae i fumigated plots was suggested as a con tributing factor. Fumigation of Mary land soils prior to planting with cor resulted in P deficiency, reduced P up take, and reduced yield (Kunishi, 1989) Therefore, the results of fumigatio must be understood and interpreted i the context of different environments i used to reveal the full yield potential o a crop.

Crop rotations also help to reduc weed and insect problems. When th same crop is grown year after year, thos weeds similar in biology to the crop be come a serious competitor and are ofte difficult to control. The increasing in festation of winter wheat in the Pacifi Northwest with jointed goatgrass pro vides an example. By including sprin crops in the rotation, this weed can b suppressed. Corn rootworm is a seriou pest of corn when grown after anothe

Table 4. Influence of a one year break to green peas (spring) sudangrass (summer-fall) compared wit continuous potatoes on the need to fumigate for maximum yield.

Previous Crop	Fumigation[1]	Yield[2] 1980	1981
		--- Mg/ha ---	
Potatoes	No	10.7b	8.4b
	Yes	12.6a	11.7a
Peas-sudan	No	12.6a	10.2a
	Yes	13.1a	11.4a

Cook, 1984 (unpublished data of G. D. Easton and M. E. Nagle).
[1] Fumigated in 1980 with 1,2 dichloropropene, 1,2 dichloropropane (D-D) plus chloropicrin, 234 L ha^{-1} fumigated in 1981 with 1,3 dichloropropane plus 17% chloropicrin (Telone C) at 257 L ha^{-1}.
[2] Values followed by the same letter are not significantly different at P = 0.05.

corn crop, and insecticides are necessary for control. When corn is preceded by one or two years of another crop in the rotation, the life cycle of the insect is interrupted and the amount of insecticidal control can be reduced (Olkowski, 1986).

Risk reduction

In addition to the numerous biological benefits from crop rotation and diversity, farmers can reduce some of the inherent risks. Reports from the Midwest during the drought of 1988 indicated that yields in rotational systems tended to be higher than in monocultures (Kirschenmann, 1989; Mends et al., 1989). Also, many farmers with rotations had less cash invested in production inputs and thus had less to lose in a crop failure. Goldstein (1989) proposed the idea of "drought-proofing the farm" in low-rainfall areas through the development of rotation-based cropping systems that increase soil organic matter, improve soil structure, and ultimately conserve more moisture for the crop. The final outcome of the atmospheric changes now underway is unknown, but less stable weather patterns are likely. Thus cropping systems that are more resistant to adverse weather reduce the associated risks.

Social, economic, and environmental considerations

Diversification through crop rotation affects farm resource use and aspects of environmental quality. Mixed cropping can lead to greater economic stability, this especially with the inclusion of livestock. Farm diversification leads to more efficient use of resources, greater potential for recycling waste products, a more even demand on labor and equipment, and better nutrient cycling in the soil (Kirschenmann, 1989). Cover crops can reduce both soil erosion and nitrate leaching, thus protecting both surface and ground water quality. As world petroleum supplies shrink and prices escalate, cropping systems less reliant on oil-based inputs will be at a competitive advantage.

Along with meeting the demands for environmental quality, diversified cropping systems can also address some consumer concerns about food safety. Those systems that reduce pesticide use in farm production reduce the chance for chemical residues in the food. However, these potential benefits must be weighed against the potential increase of natural microbial contaminants such as fungi that produce carcinogens (American Council on Science and Health, 1986). The impact of production systems on the nutritional quality of food remains a controversial issue, but some data point to detectable differences in the vitamin and mineral content of crops produced under different farming methods (Schupan, 1974). Advocates of the family farm in American agriculture suggest that diversified farming keeps more farmers on the land, which in turn supports the quality of life in rural communities by maintaining schools, services, and neighbors (Strange, 1988).

Constraints and future directions

Although many benefits from a diversified agriculture are possible, several constraints inhibit a move in that direction (Granatstein, 1988). Government farm policy has been recognized as a significant constraint on the adoption of more diversified crop rotations (Goldstein and Young, 1987). Proposals for the 1990 Farm Bill that include increased flexibility in crop acreage base, historic yield levels, and incentives for crop rotation may relieve this constraint.

For some farmers, diversification would require new machinery or facilities not feasible in situations in which high debt continues to be a problem. Also, many farmers would need to develop new management skills and means for access to information sometimes unavailable about alternative systems. Markets for rotational crops can be uncertain and pose a significant risk. For example, with the U.S. government farm program, grain farmers have had a guaranteed market. If they included a legume such as alfalfa in their rotation, they would lose their grain base, and with no livestock enterprise, the marketplace may not be able to absorb large increases in alfalfa supply. Farming decisions can also be influenced by lending institutions, which may be adverse to the purchase of new equipment to produce a risky crop.

Along with the interest in farm policy changes that would allow cropping diversification, changes in agricultural institutions and societal perceptions are emerging. Farmer-research-extension-community linkages are being expanded and made more multi-directional in an effort to tap the large amount of existing on-farm knowledge (Francis, 1986). Federal, state, and private programs are available to help farmers with on-farm testing and to communicate successes and failures to other farmers, researchers, policymakers, and the general public (Granatstein and Goldstein, 1988).

The U.S. public's awareness of the importance and problems of agriculture is currently growing as a result of publicity about controversial agrichemicals and the economic plight of farm families during the 1980's. Cropping diversification and crop rotation, innovation in farm equipment, and a greater reliance on biological control and biotechnology are a few of the possible strategies for meeting the needs of both farmers and consumers. To realize these changes, the stewardship ethic expected of those who work the land must be shared by those who benefit from the land's productivity.

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INSTITUTE NEWS

DeWitt elected President of IAA Board

Dr. Jerald DeWitt, Associate Director of the Cooperative Extension Service at Iowa State University, was elected President of the IAA Board of Directors at its March meeting in Washington, DC. Ms. Maureen Hinkle of the National Audubon Society was named Vice President; Mr. Jim Bender, farmer from Nebraska, was named Treasurer; and Mr. John A. Harris, IV, of Berwyn, Pennsylvania, was named Secretary.

The Board adopted a long-range plan for the Institute, which includes prompt expansion of its work in relation to the 1990 Farm Bill and other national sustainable agriculture policy initiatives. The 1991 IAA symposium will focus on the true costs of food, including environmental and health factors, the Board decided.

President's Council of national leaders formed at IAA

Twenty-five nationally known leaders in agriculture and natural resources have been named by the IAA Board of Directors as charter members of a President's Council at the Institute. The Council will provide guidance and support for Institute activities in furthering a more scientifically, economically, and environmentally sound agriculture.

Members of the President's Council for 1990 are: Patrick Leahy, U.S. Senator from Vermont; John C. Gordon, Yale University School of Forestry and Environmental Studies; Fred Kirschenmann, Kirschenmann Family Farms, North Dakota; William Marshall, Pioneer Hi-Bred International; Ned S. Raun, Winrock International; R. Jim Hildreth, the Farm Foundation; Richard J. Sauer, National 4-H Council; Edward Sills, Pleasant Grove Farms, California; Norman Berg, Soil and Water Conservation Society; Edith N. Muma, Jessie Smith Noyes Foundation; David G. Topel, Iowa State University; Ralph Grossi, American Farmland Trust; Dennis R. Keeney, Leopold Center, Iowa State University; Dana Jackson, The Land Institute; Karl N. Stauber, Northwest Area Foundation; Robert Gray, Resource Consultants; Ronald Rosmann, farmer from Iowa; Dan Martin, MacArthur Foundation; George Brown, U.S. Representative from California; Bill McCalpin, Rockefeller Brothers Fund; Bob Bergland, National Rural Electric Cooperative Association; Lester Brown, World Watch Institute; Mrs. David Rockefeller, New York; Ron Ellermeier, farmer from Nebraska; R. Neil Sampson, American Forestry Association.

Youngberg, Francis, Harwood contribute to Senate report

IAA Executive Director Garth Youngberg and *AJAA* Editorial Board member Charles A. Francis co-authored the lead article on sustainability for the U.S. Senate Agriculture Committee background publication *Reform and Innovation of Science and Education: Planning for the 1990 Farm Bill.* Youngberg and Francis supported the idea that sustainability should be an overall goal for farm bill programs and proposed a panel to formulate guidelines and criteria for a practical definition of the term.

AJAA Board member Richard Harwood also contributed a chapter to the committee publication on "International Forces for Agricultural Sustainability and Their Influence on U.S. Agriculture." Harwood proposed a

small grants program that would be aimed at training groups of applied scientists at land grant institutions to become experts in sustainable approaches that could be common to both U.S. and Third World agriculture.

Limited copies of the publication were printed for use of Congressional members in preparing for 1990 Farm Bill discussions.

James Aidala to be IAA Director of Policy Development

James V. Aidala, Jr., formerly an analyst in environmental policy at the Congressional Research Service in Washington, DC, has been named Director of Policy Development at the Institute for Alternative Agriculture. Aidala will provide leadership for the Institute in 1990 Farm Bill discussions and other policy initiatives related to sustainable agriculture. In addition to his work at the Congressional Research Service, Aidala has been a staff member of the Senate Governmental Affairs Committee and a program analyst at the Environmental Protection Agency.

Aidala holds BA and MA degrees from Brown University, where he graduated Magna Cum Laude, was elected to Phi Beta Kappa, and was awarded the Lester Ward Prize for most outstanding student in sociology. Aidala also holds an MA degree from Harvard University, where he has completed course requirements for the Ph.D. degree in sociology.

Institute supports Jontz bill on sustainable agriculture

The Institute joined 21 national, regional, and state organizations in supporting the Sustainable Agricultural Adjustment Act (HR 3552) introduced by Congressman Jim Jontz of Indiana in December, 1989. The bill would remove commodity program barriers to crop rotations and provide incentives for producers to develop five-year farm management plans that include chemical-reduction methods. For information on the bill, contact the office of Congressman Jontz, 1039 Longworth House Office Building, Washington, DC 20515.

Miller, Young, and Cook named to *AJAA* Editorial Board

Dr. Robert H. Miller, Dr. Douglas L. Young, and Mr. Kenneth A. Cook have recently accepted an invitation to serve on the Editorial Board of the *AJAA*.

Robert Miller is presently Dean of the College of Agriculture Development at the University of Rhode Island in Kingston, Rhode Island. He holds a Ph.D. in soil microbiology from the University of Minnesota. He has been head of the Department of Soil Science at North Carolina State University and Professor in the Department of Agronomy at Ohio State University. Dr. Miller is the author of over 70 journal articles and other reports and has had a specific interest in research related to alternative agricultural systems.

Douglas Young is Professor in the Department of Agricultural Economics at Washington State University in Pullman, Washington. He holds his Ph.D. in agricultural economics from Oregon State University. Prior to his work in Washington, he was a project economist for a joint effort between Oregon State University and the U.S. Agency for International Development. He serves as Editor of the *Western Journal of Agricultural Economics*; has authored a number of articles, bulletins, book chapters, and other publications; and has worked on the economics of low-input and sustainable agriculture.

Kenneth A. Cook is Vice President for Policy at the Center for Resource Economics, Island Press, in Washington, DC. He holds an M.S. in soil science from the University of Missouri at Columbia. He has been Director of Congressional Affairs and of Press Relations for the World Wildlife Fund and The Conservation Foundation an is a widely published author and polic analyst with over 30 articles on agri cultural and environmental policy. H was principal author and analyst fo the 1985 report from the America Farmland Trust, *Soil Conservation i America: What Do We Have to Lose*

Clagett Farm/Heller receive AFT award

IAA Board member Michael Heller Manager of Clagett Farm, accepted 1989 Agricultural Conservatio Award given to Clagett Farm by th American Farmland Trust in Novem ber, 1989. The award was given to Cla gett Farm for educating farmers an the general public about the interre lationship between agriculture and sur rounding natural resources and fo providing a practical model of hov conservation practices can reduce en vironmental risks without jeopardizin profitability.

Institute joins 10 groups in environmental/consumer agenda

The Institute has joined 10 other na tional groups, including the Soil an Water Conservation Society of Amer ica, the National Audubon Society and the American Farmland Trust, i publishing an environmental/con sumer agenda for the 1990 Farm Bil The report calls for an Environmenta Stewardship Program that would pro vide funding for pollution-preventin strategies. It also provides for ex panded research in sustainable farmin systems and reform of federal pro grams to end obstacles to crop rota tions. Copies of *Farm Bill 199 Agenda for the Environment and Con sumers* are $6 each, with a minimu order of 5 copies and $2.50 postage handling. Call Island Press at 1-80 828-1302 with orders.

The role and contributions of animals in alternative agricultural systems

Frank H. Baker and Ned S. Raun

Abstract. *Livestock are important components of agricultural systems. In the U.S., one-half of total agricultural receipts come from the sale of livestock. They are the harvestors of range plants, forages, and crop residues; they level out the effects of the seasonality and variability of rainfall; they cushion disruptions in the trade and marketing of feed grains; they counteract declining soil fertility and soil erosion; and they contribute to the efficient year-round use of farm labor. Unfortunately, farmers are often not inclined to adopt alternative animal agriculture systems despite the advantages they may offer. Constraints that may be encountered include possibilities of reduced short-term profits, difficulties in adapting available technology to alternative farming systems, difficulties in shifting from specialized crop or livestock farms to crop/livestock farms, and the increased needs for labor and management. Some actions needed in the U.S. to improve livestock production in alternative farming systems are: the establishment of government policies to promote the shift of marginal lands to soil and water conserving crops and the incorporation of pastures and forages in crop rotations; research to improve the utilization by ruminants of ligno-cellulosic feeds (pastures, forages, crop residues); and programs to improve range and forest management and to lead to the development of systems that optimize the use of forages for the production of nutritionally desirable lean beef.*

Key words: conventional farming, fertilizers, high input, livestock, ruminants, rotations, pasture

Introduction

Public attention is currently focused on the modification of agricultural systems to enhance productive efficiency, economic and environmental sustainability, social acceptance, and the capacity for continuous regeneration. In discussing the changes in agricultural systems, Schaller (1988) compared conventional agriculture to the alternative systems. He stated:

> *Conventional agriculture is described in a recent memorandum by the Secretary of Agriculture as a system that is highly specialized and emphasizes high yields achieved by inputs of fertilizers, pesticides, and other off-farm purchases. Alternative farming systems, according to the memorandum, range from systems with only slightly reduced use of these inputs through soil tests, integrated pest management, and capital inputs, to systems that seek to minimize the use [of off-farm inputs] through appropriate rotations, integration of livestock with crops, mechanical/biological weed control, and less costly buildings and equipment.*

Several terms have been applied to these alternative systems; however, the one receiving recognition through the Agricultural Productivity Act of 1985 and the Agricultural Budget Bill of 1988 is "low-input/sustainable agriculture." Many of the alternative systems emphasize the synergism of plants and animals in total farm management programs involving rotations for nutrient recycling and pest or weed control with reduced dependency on external inputs and fossil fuel-based fertilizers and chemicals.

People have depended on land and livestock to yield food, by-products, and services since prehistoric ages (Getz, 1985). Today many agricultural systems continue to include animals. Outputs of these systems are meat, milk, eggs, wool, mohair, leather, fur, bone, draft power, transportation, manure, protection, companionship, and recreation.

More than half of the 2.3 billion acres of land in the United States is used to produce crops and livestock. Approximately 900 million acres of non-Federal rural land is in pasture, range, and forest that is used for livestock grazing by cattle and other ruminants. A major portion of this land is subject to erosion by water or wind, or both (USDA, 1987). There are 8.5 total acres of land per person in the United States. The ownership and use of this land in millions of acres is (a) publicly owned: range 2.81, forest 0.69; (b) privately owned: range and pastures 2.12, woodland 0.53, crops for the domestic market 1.27, crops for the export markets 0.45, crops for pasture 0.41, farmstead and roads 0.13, and idle land 0.09 (Byington and Hart, 1984).

The crop land consists of 421 million acres, of which 33 million acres are used for hay (USDA, 1987). The U.S. acreages of feed grains, hay, and silage crops for use primarily in livestock programs are shown in Table 1. Approximately two-thirds of the feed grains produced and half of the soybeans are used for livestock feeding in the U.S. Most of the balance is exported to other

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Table 1. Feed grain, hay, and silage crops harvested in the U.S.

Crop	Acres harvested (Thousands)
Sorghum for all purposes	13,514
Sorghum for grain or seed	12,679
Corn for all grain purposes	77,883
Corn for grain or seed	69,858
Corn cut for silage or green chop	9,019
Hay cut	56,744
Alfalfa cut	23,917
Small grain	2,586
Tame hay other than alfalfa, small grain and wild hay	19,100
Wild hay cut	6,746
Grass silage, haylage, and green chop	4,395

Source: U.S. Census 1983.

Table 2. Types of livestock farms[1].

Type of farm	Number
Beef except feedlots	618,555
Beef feedlots	84,961
Hogs	129,864
Sheep and goats	26,535
Dairy	164,628
Poultry and egg farms	41,971
Animal specialty farms[2]	65,040
General farms primarily livestock[3]	30,244
Total livestock farms	1,161,798
Total U.S. farms	2,240,976

Source: U.S. Census 1983.
[1] Based on more than 50% of product sales from the indicated type of livestock commodity.
[2] Includes furbearing animals, rabbits, horses, mules, donkeys, ponies, bees, fish worms, and other animal specialties.
[3] Includes farms receiving 50% of income from livestock products, including animal specialties, but less than 50% from any single livestock or livestock product group.

Table 3. Economic importance of livestock and livestock products.

Source	% of total agricultural receipts from livestock
Meat animals	29
Dairy products	12
Poultry and eggs	7
Other animals	1
Total animals	49

Source: Agricultural Outlook, USDA/ERS, August 1988.

countries.

Fifty-two percent of the farms in the U.S. are classified as livestock farms (Table 2). Overall, nearly half of the cash receipts in agriculture come from the sale of livestock products and livestock (Table 3).

Roles of animals in production systems in the U.S.

The interaction of animals and plants with the nonliving parts of the environment such as soil and climate creates an ecosystem (Jacobs, 1986). If the ecosystem involves primarily domesticated animals and plants under man's management or direction, it is called an agroecosystem. There is both competition for and synergism in the use of resources in these systems. In many instances, a stable biotic community or balance among plants and animals is established. This balance involves cycling of carbon, nitrogen, and mineral matter through the soil, plants, and animals. Surplus plant material becomes food for animals and animal waste or by-products become plant food material. Alternative agriculture methods use the natural plant-animal interrelationships to improve the ecological, biological, and socioeconomic sustainability of agricultural systems.

Pasture and forage utilization

Ruminants harvest a wide range of ligno-cellulosic materials, including range and pasture plants, cultivated forages, weeds, and crop residues and convert these materials into food and fiber. In regenerative crop/livestock systems, hay, silage, pasture, and cover crops are not only sources of nutrients, but also contribute to the maintenance of soil fertility, the improvement of soil tilth, the reduction of soil erosion, the cycling of plant nutrients, the improvement of soil nitrogen status (particularly when legumes are used), and the control of insects and weeds. In many regenerative systems, pastures, forages, and crop residues often comprise a larger proportion of the total diet for ruminants than in many traditional livestock production systems. Therefore, methods to improve the utilization of these ligno-cellulosic feedstuffs is of long-term importance.

More than half the agricultural la in the United States is in range, pastu and forest range; this area will increa as marginal land is taken out of cr production. This emphasizes the ne for efficient and sustained utilization range and pasture lands. Too often pa tures and ranges are mismanaged a short-term profit opportunities overri long-term advantages so that producti ity is reduced over time and soil erosi and land degradation result (Box, 198

Cook (1985) reviewed the work of C sen and Hansen (1977) and reported th a mix of herbivores in a diverse rang land ecosystem increases biological e ficiency because dietary variatio among species leads to more uniform u of the plant biomass compared to usi a single species. Forage selection b grazing animals is influenced by sever factors, including forage quality a availability, animal-prehensile-grazi ability (biting or pulling materials fro the plant), animal anatomy (teeth, lip and mouth structure), secondary pla metabolites, topography, animal agilit physical plant properties, and anim competition (Baker and Byington, 198 Taylor, 1985). The addition of one she per cow unit in a beef grazing operati increased annual off-take sufficiently result in a 29 percent economic adva tage compared to cattle alone (Umberg et al., 1984).

Livestock can be used to contr weeds through grazing. In some i stances, costs of weed control can reduced or crop yields can be increas and additional income obtained from a imals grazing weeds and cover crops u der high-growing crops and trees. F example, sheep were effectively used graze the understory of corn fields befo World War II. This practice has be largely abandoned with the advent mechanized agriculture and herbicid Another example is the use of catt sheep, and goats to graze out undesirab understory species in wooded are Constraints on the use of these syste are inputs required to manage the grazing animals and losses of sheep a goats to predators. In the tropics, the are many examples of using animals control weeds and understory growt

e.g., sheep grazing under rubber trees, cattle under coconut trees, multiple species (cattle, sheep, goats) grazing to control understory in African bush lands, and ducks and geese as weeders in southeast Asia.

Agroforestry

Among agroecological systems of the future, agroforestry (combining trees, crops, and livestock) offers great potential (Raun et al., 1982). One of the most promising approaches in agroforestry is that of livestock production in the forest. Such systems can be grouped into one of five categories (Byington and Child, 1981): 1) producing livestock forage under pine tree plantations; 2) integrating forage production with tree crops such as walnuts; 3) managing forests to increase off-take of wildlife for food; 4) reducing livestock grazing damage on broadleaf forests while maintaining animal off-take; and 5) planting "fodder trees" to slow deforestation in the humid tropics and desertification in the arid tropics.

Coping with rainfall deficiencies

Whether in range/pasture or crop/livestock systems, livestock can serve to level out the effects of the seasonality and variability of rainfall (Raun, 1981). For example, a growing season with inadequate rainfall for a grain crop might still produce significant amounts of vegetative material for livestock feeding. Traditionally, this has been one of the advantages of ruminant livestock, namely their salvaging of energy and nitrogen from what could have been complete crop failures in "crops only" systems.

Cushioning trade/market disruptions

Domestic animals play a major role in cushioning trade and market disruptions. For example, when feed grains are in surplus supply, lowered feed costs encourage the feeding of attractively priced feed grains. Conversely, during periods of tight supplies of feed grains, livestock numbers can be adjusted downwards or alternative feeds and feeding systems can be used, e.g., pastures and forages for ruminants.

Hardin (1978) stated, "Let us examine how the U.S. livestock industry responded to the 17 percent shortfall in grain production in 1974. Between December 1974 and November 1975, the pig crop was reduced by 15 percent from the previous year. By January 1, following the short harvest, the number of beef cattle on feed was reduced by 26 percent from a year earlier, and by April 1, 1975, it was further reduced by 30 percent from the preceding year. Total feed grain use in this country from harvest to harvest was actually reduced by 24 percent. Yet exports of feed grains were down by only 10 percent. Clearly our feeders did adjust quickly and effectively, and because they did the impact on the rest of the world was less severe than it otherwise would have been. Incidentally, wheat exports were cut more severely than feed grains, perhaps in part because there was little wheat being fed to livestock, and, therefore, no livestock buffer to draw on."

Hardin (1978) also points out that U.S. grain production for livestock feeding developed in response to consumer demand for meat. Without this large livestock feeding industry which could be adjusted downward, the U.S. response to the world grain shortage would have been much less.

Paarlberg (1969) addressed the national importance of combining livestock and crops in the total food and agricultural system. He stated, "A big adjuster is livestock...If the food supply is reduced, we eat the livestock and then eat the crops the livestock otherwise would have eaten. The potential of this adjuster is enormous. Not all countries have this shock absorber in their food supply. The U.S. has it...Some countries, as in the Middle East, have long been so near the margin of want that the livestock population is very small and there is little cushion to avert disaster."

Soil, water, and environment

Livestock play a vital role in counteracting two of the most serious problems in the environment, i.e., declining soil fertility and soil erosion. Acker (1986) stressed the role of animals in the total farm system. First, livestock manure can help sustain and build the vital soil resource (see Table 4 for nutrient content of manures). Second, in the U.S. and other developed countries, much of the crop land with sustained or enhanced productivity has benefited from nutrients and organic matter returned to that crop land from harvested feeds and feed concentrates. As technology in-

Table 4. Approximate nutrient content of several manures.

Type of livestock	Storage/ handling[a]	Total N	Ammonium (NH_4+)	Phosphate (P_2O_5)	Potash (K_2O)
		Pounds/ton			
Swine	Solid NB	10	6	9	8
	B	8	5	7	7
	Liquid P	36	26	27	22
	L	4	3	2	4
Beef cattle	Solid NB	21	7	14	23
	B	21	8	18	26
	Liquid P	40	24	27	34
	L	4	2	9	5
Dairy cattle	Solid NB	9	4	4	10
	B	9	5	4	10
	Liquid P	24	12	18	29
	L	4	2.5	4	5
Turkeys	Solid NB	27	17	20	17
	B	20	13	16	13
Horses	Solid B	14	4	4	14

Source: Sutton et al., 1985.
[a] NB = no bedding; B = bedding; P = pit; L = lagoon.

creases yield potential in developing countries, return of nutrients and organic matter to the soil will become more critical. In these countries, the large areas devoted to grazing must be managed with all the knowledge and wisdom that can be gathered. Finally, compared to crops, livestock systems have a net positive influence on the height of the water table and on water quality.

Prevention of erosion is vital to the future of agriculture. In crop land, soil loss from wind or water erosion can be minimized through cover cropping, crop rotations, and use of legume crops (Harwood, 1982). Roberts (1944) demonstrated the value of planting grass on erodible land on the Erosion Experiment Station at Guthrie, Oklahoma. Soil loss from a 6 percent slope planted to Bermuda grass was 40 pounds per acre per year compared to 20 tons per acre per year for row crop farming. In other trials, Roberts showed that eroded, abandoned crop land could be converted to Bermuda-lespedeza pasture with a carrying capacity of 1 cow per 2 acres.

In the Appalachian region, composed of 397 counties in 13 states, 56 percent of the land has been classified as having slopes too steep for normal cropping. Alternative or specialized agricultural systems using livestock are being applied through the region. Development of these systems has required consideration of the available nutrients for establishing pastures (some fertilization is often required for the first year or two), and adapted species of plants, e.g., tall fescue and Bermuda grass in humid areas. These livestock-forage systems have involved beef and dairy cattle, sheep, and goats. In addition to their positive impact on controlling soil erosion, they improve water retention, with positive effect on the water table level. They also reduce soil leaching of nitrogen and minerals with a resulting improvement in water quality.

Recycling animal wastes and crop residues

A significant proportion of the nutrients consumed in pastures, forages, and crop residues is returned to the soil. These nutrient recycling mechanisms are important in maintaining soil fertility and in reducing requirements for purchased chemical fertilizers. In contrast, soil minerals that are translocated into grain and other crops are lost when these crops are removed from the farm.

Modern alternative agricultural systems seek to be in harmony with natural systems (Harwood, 1982). Sustainability of these systems centers on interrelationships among crop enterprises, interrelationships between crop and animal enterprises, and nutrient flow and cycling based on physical and biological principles. Movement of nutrients from the fixed state to the soluble state is important in the maintenance of soil fertility. Rotations with deep-rooted crops enhance the upward nutrient flow from deeper soil profiles. Modification of tillage methods away from the moldboard plow helps control the downward flow of nutrients. Maintenance of crop residues near the surface of the profile and maintenance of the insect phase of the system enhances the incorporation of nutrients into the plant, animal, and microbial biomass, thereby increasing their retention. Thus, to maintain soil fertility in well-balanced agroecological systems, it is essential that attention be focused on the interactions between plants (crops, grasses, trees) and animals (ruminants, nonruminants, aquatic species, and insects).

By-products or wastes from one agroecosystem can be a valuable input into another (Vetter and Boehlje, 1978). Residue materials are important feedstuffs for ruminants in alternative agriculture systems. Their use depends upon the cost, availability, and nutrient characteristics of these materials in comparison with alternative feedstuffs. T
Stanford Research Institute (S
(1976) made an extensive evaluatio
the use of agricultural residues. T
compilation included a county/state
vey and represents one of the first
tailed assessments on the use
distribution of these residues. The
summary (Table 5) shows a total resi
production of 474 X 10^6 dry tons (D
considerably below the 730 X 10^6 me
DT estimated by Heichel (1976). H
chel estimated 300 X 10^6 metric DT
livestock wastes, assuming 50 to 80
cent of the animals in confinement,
430 X 10^6 metric DT of crop resid
His estimate, however, did not incl
forestry residues.

Labor and social values

Unused labor of farm operators
their families is sometimes a signific
problem at certain seasons and so
times throughout the year. If off-f
employment is not available, the
alternative is to modify the farm
gram to use the available labor m
fully. The addition of livestock en
prises is quite helpful in making m
efficient year-round use of farm lab

Livestock may increase the fami
pride in their farm and their satisfac
with farm life. Many people find it
to identify with animals and enjoy be
producers and caretakers of livest
This relationship with animals o
brings farm operators into closer a
ciation with the biology of farming
with nature.

Table 5. Distribution and use of total agricultural residues.

Use	Agricultural residues (dry tons × 10^6)			
	Crop residues	Manure	Forestry	T
Returned to soil	237	25	—	
Fed	61	—	—	
Sold	13	5	38	
Fuel	9	—	19	
Wasted	2	6	59	
Total	322	36	116	
available	278	26	114	

Source: Stanford Research Institute, July 1976.

Special roles of livestock in the tropics

Having some understanding of the roles of animals in the tropics can be helpful in the development of alternative animal agriculture production systems in temperate climate, developed countries.

Utilization of marginal lands

Approximately two-thirds of the world's domestic ruminants are located in the tropics (Raun et al., 1982). They help to optimize total agricultural output by producing meat, milk, fiber, and traction power on vast areas of land that are not suitable for cropping (over two-thirds of the agricultural land) and by using forage vegetation, crop residues, and waste products that are not destined for human consumption.

Utilization of ligno-cellulosic materials

Ruminants harvest a wide range of ligno-cellulosic materials, including range and pasture plants, cultivated forages, tree foliage, weeds, and crop residues, and convert these feeds into products that are useful to man. Ruminant animals promise to become even more important in tropical regions in converting biomass into energy (food, fiber, and traction power) and in minimizing the use of fossil fuels.

Tropical pasture and shrub legumes are of special importance in regenerative farming systems. These deep-rooted legumes significantly ameliorate soil-weathering processes and improve soil fertility. They symbiotically fix atmospheric nitrogen. Their deep root systems bring soil nutrients to the surface and also help hold the soil, reducing erosion problems. Several leguminous tree species are now being studied for use in alley cropping and protein bank systems, e.g., *Leucaena leucocephala*. These species provide high protein foliage to correct the protein deficiency of pasture grasses, particularly during the dry season. They also produce timber for posts and building material and wood for fuel. They assist in reducing soil erosion caused by wind and by water runoff.

Components of crop/livestock systems

At least 75 percent of ruminant livestock and practically all poultry and swine are found on crop/livestock farms. (Raun et al., 1982). Livestock account for approximately one-third of total farm production, i.e., products both for sale and for use on the farm.

The ecological, biological, social, and economic sustainability of these crop/livestock systems depends upon the livestock component. Livestock are the harvesters of the forage and tree (foliage) crops that are needed in crop rotations. Meat, milk, and fiber augment income, provide cash to purchase inputs for crop production, and provide food and fiber for home use. Livestock replace hand labor in weeding, e.g. sheep grazing under rubber trees, cattle grazing under coconut trees.

In these systems, livestock provide at least 75 percent of the traction power and transport. This means that small farmers do not have to buy tractors and fuel, which they generally cannot afford. This power source matches their skills and resources and enables them to shift from hand labor to animal draft systems. Also, it enables many limited resource producers to expand their operations into newly developing areas.

These relationships are highly synergistic. Solar energy is transformed through plants and livestock into food, fiber, income, and traction power; animal wastes are cycled back to the plant system; crop rotation options are expanded; and labor required for weed control is reduced. As a result, overall farm productivity and sustainability are increased.

Buffer against climate

Livestock buffer the effects of climate. They salvage energy and nitrogen from droughty crops that would have been complete crop failures in "crops only" systems. On the other hand, during periods of adequate feed supplies, ruminant animals increase food reserves in two ways: by accumulating proteinaceous and fatty tissues that are available for body use during extended periods of deficient nutrient intake, and, just as domestic animals serve as living food reserves, they also are living banks of stored capital, providing financial reserves in periods of economic stress and a source of capital for financing on-farm agricultural investments. For example, tribal groups in Africa consider animals as the best insurance against uncertainty of rainfall and destruction of crops by pests. In Latin America, swine are probably the most important scavenger species in transforming surplus feedstuffs such as bananas and cassava into living "piggy banks."

Constraints to livestock production in the U.S.

Unfortunately, farmers are often not inclined to adopt alternative animal agriculture practices and systems despite their advantages. The constraints on the adoption of alternative animal agriculture systems arise from economic factors, technology, crop mix, and available labor and management.

Economics

Livestock producers are confronted with both short- and long-term constraints to changing production practices and systems. Short-term profit opportunities will generally override investment in longer-term ventures, even though the latter may be more sustainable and profitable over time. Also, existing investments in land, facilities, and equipment often make it difficult for producers to identify the capital needed to shift to alternative production systems.

In both cases, it is risky to depart from short-term profit opportunities and to change existing production systems. To overcome these risks, the producer must be convinced that the longer-term returns to capital in alternative farming systems are sufficiently high to warrant these investments. Also, the producer must be philosophically disposed to accept that the most profitable and sus-

tainable system over time may not have the highest level of production in the short run.

Technology

Even though existing production technology can be adapted to a wide range of regenerative farming systems, there nonetheless are technological barriers to be overcome. The most critical need is for technology that integrates crop, pasture and forage, and livestock components. Alternative feeding systems for ruminants will place increasing dependence on pastures and forages. Therefore, additional technology/technology packages are needed for crop/forage rotations, forage harvesting and handling, forage quality and utilization, and utilization and storage of crop residues. For nonruminants, few changes in feeding systems will likely be needed.

For beef cattle in particular, there is a need to modify and develop feeding and breeding systems to produce meat with more edible lean and less fat. Research is needed on processing methods to reduce fat content of retail meat products and to develop new meat products that match consumer demand.

Crop mix

The family, multi-commodity farms of a generation or so ago have been largely replaced by larger, specialized crop or livestock farming enterprises (OTA, 1985). For instance, family farms in the midwest that included grain, oilseed, and forage crops along with cattle, sheep, hogs, and poultry have largely evolved into units dominated by one or two grain crops with little or no forage/pasture and livestock. Those family farms that have livestock are usually limited to a single species in an intensive, confinement-based system. The shift to monocrop grain farming systems has exacerbated excessive grain production and burdensome surpluses. In addition, this has resulted in the needless use of nonrenewable resources and in the degradation of marginal lands as they have been converted from pasture or forest to crops.

These intensive, monocrop/monospecies systems have become increasingly reliant on chemical fertilizers, herbicides, insecticides, and other chemicals and have drifted away from crop rotations and other desirable cultural and animal husbandry practices (Harwood, 1984). Although it will be difficult to make changes in some high-input monoculture/species systems because they are so commodity specific, there nonetheless are many changes that can be effectively made, such as integrated pest management, better weed control, and more use of cover crops and crop rotations.

Labor and management

Many livestock producers are disposed to adopt alternative production practices and systems but are prevented from doing so either by the high cost or shortage of labor or by inadequate skills to manage a different type of enterprise. The shortage of experienced farm labor is reflected in the observed trends in increased mechanization and farm size and shifts to monoculture systems. Although producers often recognize the merits of many alternative farming practices (e.g., incorporation of pastures and forages into crop rotations, harvesting and utilization of crop residues), they may not implement them because of labor shortages during the growing season.

Management skills are often lacking. Whereas most farmers of a generation ago had skills in livestock production, today such farmers are a distinct minority. In addition, most of today's farmers are probably not inclined to include livestock in their farming systems.

Actions needed in the U.S. to improve livestock production

Most farmers will consider and adopt alternative practices that will protect and improve natural and renewable resources and that will contribute to making farming systems more stable and sustainable. They are generally motivated to be good caretakers of the nation's agricultural resources. But, however noble and worthy this caretaker ethic may be, they ultimately make farm decisions based on the sustainability and economic return of any system or practice. Of the many actions needed to advance alternative agriculture programs the following are highlighted.

Policy development

Federal and state governments should establish policies that will promote the development of regenerative agricultural practices and systems that are ecologically, biologically, and socioeconomically sustainable. Policies are needed to provide incentives to shift marginal cropland into soil and water conserving crops, i.e., pastures, forages, and tree crops. Each farm should have a cropland acreage base that considers all farm program crops independent of historical acreage in order to encourage production of soil-conserving crops, e.g., pastures, forages, tree crops. Conversely, disincentives are needed to discourage farmers from placing rangelands, forests, wetlands, and erodible lands into crop production.

Pastures and forages in rotations

It can be argued that the importance of pastures and forages is declining because cattle production is becoming increasingly intensive and specialized and increasingly reliant on feed grains and other concentrate feeds. Even so, there still are many crop/livestock (ruminant) farms that utilize pastures and forages in feeding systems for ruminants. These farms often have economic and environmental advantages over their crops-only counterparts. Therefore, government farm program policies should be changed to consider pastures and forages used in crop rotations as part of the cropland acreage base. This would promote crop rotations, improve pest and weed control, favor environmental protection and enhance farmers' interest in crop-livestock systems.

Utilization of ligno-cellulose

As previously mentioned, pastures and forages are key components of regenerative crop/livestock system

Therefore, identifying methods to improve the utilization of these ligno-cellulosic feedstuffs is of long-term importance. Research is needed in several areas: to develop pastures and forages that produce higher levels of digestible energy and protein for ruminants (Wedin, 1980); to develop microbiological, chemical, and physical methods to improve digestibility of high-fiber feedstuffs (Oltjen et al., 1980); and to develop feeding systems that optimize the use of forage in the production of lean beef.

Pasture, range, and forest management

Area in rangeland and pastures increases as marginal land is taken out of crop production in many alternative agriculture systems. Although basic range and pasture management technology is available, pastures and ranges are often mismanaged and short-term profit opportunities override long-term advantages. Consequently, productivity is reduced over time; and soil erosion and land degradation result (Box, 1981). Therefore, research and producer education are needed on range and pasture management, forest/range systems, multispecies grazing systems, and the use of grazing to control weeds.

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Farm profiles invited

For its new department on alternative agriculture profiles, the AJAA welcomes short articles describing farmers who have adopted interesting alternative practices. The articles should include five elements: a brief description of the farm; the problems that made the farmer look for an alternative approach and the reasons why the alternative seemed plausible; a summary of the basic principles behind the alternative (possibly in a sidebar if it interrupts the flow of text); a discussion of how well the alternative has worked; and a discussion of the applicability of the alternative for other farms. The length should be 1500 to 2000 words.

Submissions must be accompanied by a release, signed by the farmer, giving permission for this material to be published in the *American Journal of Alternative Agriculture*. Vol. 3, No. 4, of the AJAA has a further description of the department (page 188); or query the editor for further information. Send submissions to the Editor, AJAA, 9200 Edmonston Road, Suite 117, Greenbelt, MD 20770.

Widespread adoption of non-conventional agriculture: Profitability and impacts

Sandra S. Batie and Daniel B. Taylor

Abstract. *Conventional agriculture is increasingly criticized as being too concentrated in ownership; too reliant on technology, petroleum-based inputs, and credit; too specialized and ecologically unsound; and too dependent on government subsidies. Alternative agriculture is offered by many as an alternative, and we discuss the possible impacts of its widespread adoption on farm income, yields, regions, labor, trade, environmental quality, and farm structure. The profitability of alternative agriculture is also examined - in so doing, a distinction is made between the adoption of low-input practices and a more holistic alternative agricultural system.*

Key words: organic agriculture, conventional agriculture, low-input agriculture, alternative agriculture, fertilizers, pesticides

Introduction

Conventional agriculture can be defined as a production system that employs a full range of pre- and post-planting tillage methods, synthetic fertilizers, pesticides, antibiotics, and hormones (Cacek and Langner, 1986). As such, it is increasingly indicted as being too concentrated in ownership; too reliant on technology, petroleum-based inputs, and credit; too specialized and ecologically unsound; and too dependent on government subsidies.

Conventional agriculture is frequently contrasted to alternative agriculture. Definitions of terms such as "alternative," "low-input," and "organic" agriculture are abundant in the literature but are not used consistently. There is a wide range of production systems between conventional agriculture and organic agriculture, as well as a spectrum of opinions with respect to the desirability and feasibility of these systems.

For the purpose of this article - discussing the profitability and impacts of broad adoption of non-conventional agricultural practices - we distinguish between two broad classes of production systems: low-input agriculture and alternative agriculture. We define low-input agriculture as a farming system in which the direct or indirect use of purchased petrochemical-based inputs is reduced relative to conventional agriculture. We define alternative agriculture as a more holistic concept than low-input agriculture; it includes aspects of the quality of rural life and economic revitalization of rural areas. In this paper, we will also use the encompassing term "non-conventional" when discussing issues that apply to both low-input and alternative agriculture.

Both low-input and alternative agricultural systems are increasingly perceived as attractive alternatives to conventional practices. There are hopes that they will prove to be so superior to conventional agriculture that they will be adopted on a wide scale, resulting in many positive impacts, such as enhanced environmental quality. Many people also believe that wide-scale adoption of non-conventional agricultural practi will lead to rural revitalization, regio self-sufficiency, and a restructuring[1] the agricultural production system.

Policymakers are interested in ad tion of non-conventional systems cause of their potential positive impac They are increasingly asking about gains and losses from wider adoption non-conventional agricultural practi as well as the identity of the recipie of these gains and losses.

Due to both conflicting and limit research results, the answers to th policy-relevant questions are not vious. Analysis of the impacts of wi scale adoption of non-conventional pr tices is exceptionally sensitive to the searchers' assumptions about economic potential of non-conventio practices. Also, differing assumptio can produce disparate policy impli tions.

In this paper, we first identify cr cisms of conventional agriculture a the possibility that non-conventional riculture can provide constructive sponses to these criticisms. We th briefly examine the profitability of n conventional agriculture, suggest that the profitability of alternative riculture as a system is different fr the profitability of selected low-in practices. We follow with a discussi of possible impacts of widespread ad tion of non-conventional agricult practices on farm income, yields, gions, labor, trade, environmental qu ity, and farm structure.

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[1]Structure is defined as the organization of the f sector, size, management, operational features, the f of the farm business, ease of entry and exit, the mul job holding patterns of farm families, and the mann which food and fiber is marketed (Penn, 1979).

Criticisms of conventional agriculture

Conventional agriculture has many characteristics that have been widely criticized. For example, the structure of conventional agriculture systems can be characterized as dualistic. That is, the U.S. agricultural sector has few farms providing most of the agricultural products. In 1987, 47.4 percent of gross farm sales were captured by only 4.3 percent of the largest farms (Hallberg, 1988). In 1980, 0.4 percent of all feedlots produced 53 percent of the fed cattle (Knutson et al., 1983).

There is also considerable evidence of concentration in farm product markets. As an example, in the majority of states, 60 percent of the fed beef, sheep, and hogs are purchased by the four largest meat packers (Stoddard, 1980). Similar concentration exists within retail marketing firms. For example, the four largest cereal firms sell 81 percent of the breakfast cereals; the four largest soft drink firms sell 86 percent of the soft drinks (Wallace, 1988).

Concentration also exists on the input side. In the early 1980s, a federal trade commission study found that the four largest fertilizer firms had 35 percent of the market, the four largest pesticide firms had 57 percent of the market, and the four largest combine manufacturers had 83 percent of the market (Leibenluft, 1981).

Concentration of agriculturally based firms and farms has led to migration from rural areas. This migration has resulted in a declining economic base in rural communities as well as the continuing loss of family farms. In 1985, only 5.6 million people, or 2.4 percent of the population, lived on farms (Galston, 1985).

Furthermore, as Hallberg (1988) notes, absentee ownership is now an important characteristic of conventional agriculture. While in 1982, 59.2 percent of the farms were operated by full owners, only 34.7 percent of the acreage was operated by full owners.

Conventional agriculture is a mechanized agriculture that has high labor productivity. Currently there is about $35,000 worth of capital invested per agricultural laborer; this ratio is one of the highest ratios of any industry in the United States (Foster, 1988). The high ratio of capital investment is not surprising when one considers that many of the technological developments in U.S. agriculture have been labor saving (Ruttan, 1982). Furthermore, Evenson and Kramer (1988) show that non-farm wages have had a strong influence on encouraging specialization of farms. Rising non-farm wages require higher wages on farms in order to attract workers to agriculture. Therefore, it has been cost effective for farmers to substitute specialized machinery for this labor, rather than to compete for labor with the non-farm sector (Pfeiffer, 1983).

The historic substitution of capital for labor in U.S. agriculture has its critics; a widely reported example has been the invention of the tomato harvester, which ultimately led to a court case. California Judge Raymond L. Marsh ruled that research on the tomato harvester, conducted by the University of California, assisted in the "industrialization" of agriculture. The judge found the university to be in violation of the Hatch Act because researchers did not adequately consider the consequences of their work on the family farm and farm labor (Batie, 1988).

Conventional agriculture is also technologically based and science based. It relies on the use of hybrids, petroleum-based inputs, and other products of science, as well as on credit. Just as machinery has been used to substitute for labor, technological changes such as genetically improved varieties, confined feeding operations, irrigation, and agricultural chemicals, have been used as substitutes for land. That is, rather than increase farm output by adding more acres, farmers used production-enhancing inputs to garner higher yields per acre. This land substitution began to take place in the 1930s and undoubtedly was encouraged by the federal government's acreage diversion programs, which were aimed at reducing surplus production (Evenson and Kramer, 1988; Flora and Flora, 1989). As a result, today's conventional agriculture is highly specialized, with considerable dependence on off-farm purchased inputs.

Conventional agriculture tends to be monocultural and is characterized by the lack of crop rotations and lack of incorporation of ecological concepts (Foster, 1988; Reichelderfer and Phipps, 1988; Coleman, 1982). That is, the conventional agriculture production system is "a capital-intensive agricultural system weighted by output towards larger specialized monocrop units heavily dependent upon non-renewable, resource-based inputs of non-farm origin" (Foster, 1988). This capital-intensive conventional American agriculture has been described as degrading for both the environment and the community (Hayden, 1984):

"...it is an international agribusiness that...destroys topsoil and water supplies; poisons ground and surface water supplies with chemicals, pesticides, and fertilizers; augments desertification; destroys soil humus and porosity, which means less water retention, which means that compacted soil needs larger tractors which further compact soil; leaches nutrients from and adds salts to the soil through irrigation; uses more energy than it produces; causes worker sterility in the fertilizer factories; creates health problems for farmers who apply the toxic fertilizer, pesticides, and herbicides; uses fertilizers which prevent plants from absorbing nutrients necessary for human health; fills the food chain with carcinogenic pesticides, herbicides, growth hormones, and antibiotics; creates an expensive and unnecessary transportation system;... processes the nutrients out of what food is produced, with the profits being greater the greater the amount of processing; and fills the processed product with carcinogenic preservatives, refined sugars, salt, and artificial colors."

Although evidence is mixed (Evenson and Kramer, 1988), many critics claim that the current structure of conventional agriculture is a direct result of agricultural policies, credit policies, tax policies, and research policies that have exacerbated trends towards concentration and specialization (Buttel and Gertler, 1982). It is clear that the comparative advantage of agriculture in many regions has been altered by access to subsidized inputs such as irrigation

water and barge transportation, as well as by protection from prosecution for environmental damages. Furthermore, the negative impacts of modern agricultural practices on soil and water quantity and quality, as well as on human health, seem less defensible because of the surplus production that results from agricultural commodity programs. Over 90 percent of the chemicals detected in ground water have come from crops that are already in surplus (Foster, 1988).

Alternative and low-input agriculture

Non-conventional agriculture is seen as a response to these criticisms. Low-input agriculture reduces reliance on chemicals. That is, as we define it, low-input agriculture can be thought of as a set of practices that requires less purchased petrochemicals than a set of conventional practices. Alternative agriculture is more encompassing in its definition. It is labor intensive, substituting labor and management time for machinery and chemicals. It is more self-sufficient (Bealer and Dalecki, 1985) and uses less purchased inputs than does conventional agriculture. It involves more land and fewer petroleum products. Alternative agriculture has a reduced dependence on the larger industrial society and is characterized by more regional self-sufficiency. It has been characterized as diversified and holistic, "in tune" with ecological concepts, healthful, environment and community enhancing, and responsive to broad social goals (Lockeretz, 1986).

Alternative agriculture can be thought of as embodying an alternative philosophy to that expressed by conventional agriculture. Conventional agriculture incorporates the values of a modern industrialized society; that is, increased production is good, expanding foreign markets are to be pursued, materialism and profit orientations are appropriate. The philosophy includes the belief that man should dominate over nature (Andrews, 1985; Coleman, 1982) and that science and technology are linked to progress. It is nationalistic. It is individualistic (Kaufman, 1985; Dahlberg, 1985).

Alternative agriculture involves a more holistic philosophy, incorporating alternative values to those of conventional agriculture: family and group self-reliance, harmony with nature, a global village view of the world, a respect of nature and ecosystems, a voluntary simplicity, the goal of sustainable economic growth, and a belief in the "goodness" of the family farm (Dahlberg, 1985). To quote Lockeretz (1986) in reference to the views of various authorities on the nature of alternative agriculture:

"...Some alternative agriculturalists look beyond specific production techniques to consider the structure of the agricultural sector as a whole and its relation to the larger economy. This group usually favors small to moderate sized farms, especially independent, family farms worked by resident owner-operators. They also seek to reduce the ties to the industrial economy and instead to increase the self- sufficiency of farms. Thus reducing fossil fuel use is seen as desirable not only because fossil fuel is a finite resource, but also because farmers must buy it from a powerful economic entity over which they exert no control...On the output side they favor more direct sales to consumers, with less reliance on intermediates such as transporters, processors, distributors, and packers. This change implies that more of the consumer's food supply will come from sources that are close both geographically and in the sense of having passed through fewer hands. Typically, a greater portion of the diet is expected to be in the form of unprocessed or 'minimally processed' foodstuffs."

Thus, this holistic philosophy leads to a definition of alternative agriculture as an agriculture which is economically viable, ecologically sound, socially just and humane (Luna, 1988). Alternative agriculture provides a vision of the future, "a vision of what could be if we choose a different set of objectives; a vision of agriculture that exploits neither the land nor the people" (Luna, 1988). Conventional agriculture and alternative agriculture are not merely a set of different choices; they embody different points of view about the role of pesticides in food production, home-grown produce, lifestyles, and small farms (Libby, 1985).

These different points of view can in fluence analyses of the feasibility an desirability of alternative, low-input, c conventional agriculture. Factors influ encing the adoption of low-input prac tices from a smorgasbord of choices wi be different than those influencing adop tion of alternative agriculture as a ho istic system. Impacts of wide-scal adoption of low-input practices may als differ from wide-scale incorporation c alternative agriculture philosophies. In deed, values held by analysts and re viewers, both with respect t conventional and alternative agricultur philosophies, may preselect and shap some of the factual awareness that i incorporated within empirical studie (Sheppard, 1985).

Profitability of non-conventional agriculture

Studies of the profitability of eithe low-input practices or alternative agr culture systems are limited, althoug there is more research available on th profitability of potential low-input prac tices such as rotations, integrated pe management, or manure managemer than of alternative agriculture systems

There have been at least three type of studies examining the economics c non-conventional agriculture. First a the direct comparisons of net returns c non-conventional agriculture and co ventional farms; second are the analyse of net returns based on research pl data; and third are the modeling com parisons between non-conventional an conventional farms (Cacek and Langne 1986). Some authors who have reviewe these three types of studies conclude th non-conventional agriculture, as it currently practiced, is at a disadvanta because it is generally less profitab than conventional agriculture (Crosso and Ostrov, 1988; Crosson and Eke 1988). Taylor (1989) asserts that the is no unequivocal evidence as to the pro itability of non-conventional agricultur the research results are often strongl influenced by assumptions about pric yield, technological options, risk att tudes, and future agricultural policie Other reviewers conclude that non-co

ventional agricultural systems can succeed and be profitable (Benbrook, 1987). Clearly there is individual farm anecdotal evidence of successful non-conventional agriculture enterprises, although individual profitability may be the result of excellent management as much as employing fewer purchased inputs.

Cacek and Langner (1986) suggest that some of the reasons for disparity among the studies' results are due to on-farm unmeasured benefits. For example, profits from non-conventional agricultural farms have more resiliency and tend to be less vulnerable to drought. Nutrient conservation on non-conventional agricultural farms stemming from the dynamics of carry-over of nitrogen products have not been modeled well (Norris, 1988), nor have the better seasonal distribution of inputs or adjustments of yields after a transition period (Halloway and Hoag, 1989). Because of these additional considerations, non-conventional agriculture may be more profitable than many economic studies suggest.

Farmers are increasingly experimenting with and adopting potential low-input practices such as integrated pest management. Such experimentation is consistent with the tendency of farmers to adopt parts but not all of certain technologies and practices (French and Schmitt, 1985; Buttel et al., 1986). For example, they may use low-input agricultural practices for disease control or fertilization needs but rely on chemical weed control. In a survey of New York state farmers, Buttel et al. (1986) found that 7.3 percent of the farmers used no pesticides or chemical fertilizers, 9.9 percent of the farmers used no chemical fertilizer, and 5.2 percent used no pesticides in their operation. Buttel at al. also estimate that, nationally, 52 percent of wheat, 42 percent of sorghum, and 59 percent of (combined) rye, oats, and barley are produced without pesticides. As another example, 20 percent of the nation's table grapes are organically grown in California (Blair, 1989). That is, farmers can and do adopt some low-input agricultural practices without necessarily adopting the more holistic, whole-system approach of alternative agriculture.

Opportunity sets and policy options

It is important to realize, however, that the factors that influence adoption rates of any technologies or farming systems include those that comprise farmers' "opportunity sets." That is, farmers make choices within "opportunity sets," and the current "opportunity sets" are conditioned by farm programs, environmental constraints, credit and tax policies, and integrated contracts and leases, as well as by available research on alternative agricultural and conventional practices. "Opportunity sets" are reflected in current price ratios to which farmers respond. But as the "rules of the game" change, "opportunity sets" change; and there will be a new set of benefits and price ratios that create new substitution possibilities.

The key to understanding the impacts of widespread adoption of non-conventional agriculture lies in these substitutions. For example, if farm program base flexibility is introduced, there probably will be significant short-term influences on the feasibility of non-conventional agriculture systems. Similarly, environmental regulations on the use of pesticides, taxation of fertilizers, or farmer liability for environmental damages could alter the economics of non-conventional agriculture, as could transition insurance or adoption subsidies for non-conventional farmers. Removal of the current subsidies for irrigation water or the changing of riparian or appropriative water rights could favor non-conventional agriculture systems. Similarly, current tax codes and credit policies which are not favorable for many non-conventional farmers could be changed, as could export enhancement policies, in order to favor lower residuals of pesticides, antibiotics, or hormones in food.

Other changes could also affect the economics of non-conventional agriculture. Consumer preferences may change to favor foods that have less chemical residuals, a change that could be accompanied by a willingness to pay a price premium to obtain such products (Cacek and Langner, 1986).

On the other hand, the existing structure of agriculture may limit the ability of farmers to respond to changing incentives. For example, the large numbers of part-time farmers could conceivably limit the adoption of non-conventional practices. That is, non-conventional farmers substitute labor, management time, and knowledge for machinery, pesticides and other purchased inputs, as well as credit. Just how far can management, for example, be substituted for purchased inputs? We do not know. However, management time could prove to be particularly constraining for part-time operations. For example, Norris (1988), in a study of Virginia grain farmers, found that 57 percent of the farmers indicated that they could not devote more time to managing their farm operation. Thus, more than minor adjustments in price incentives may be necessary for part-time farmers to adopt non-conventional practices.

Impacts

If widespread adoption of non-conventional agricultural production systems were to occur, the impacts of adoption would depend on how such adoption was achieved. One would anticipate, however, that widespread adoption could lead to more diversification with respect to the type, size, and ownership of farms, as well as farm income. However, it is not clear what crops would be grown and where they would be grown. The study by Olson et al. (1982) estimates very large reductions in the production of commodity crops with widespread adoption of non-conventional agriculture. Estimates of decreases such as 66 percent for cotton and 58 percent for feed grains are presented by Olson et al. (1982). But this study has been heavily criticized by others, particularly for its use of very outdated production coefficients (see, for example, Madden, 1988).

Widespread adoption may lead to lower yields, at least initially. Lower yields need not translate into lower farm incomes, however, since with lower production, farm product prices should rise. Furthermore, Taylor (1989) finds that

many micro-level studies of non-conventional agricultural systems have found lower gross incomes (due to a lower revenue per acre averaged over the rotation) but also lower production costs associated with these systems; thus they can have net income comparable to conventional systems, even at current prices. In addition, any yield penalty may be reduced if research were focused on non-conventional agricultural practices, thus limiting the rise in farm prices. Yet, technological changes operate with lags; and it will take some time to transfer profitable technologies developed through research on non-conventional systems.

Some areas might be placed at a regional disadvantage by widespread adoption of non-conventional farm practices. For example, with widespread adoption, there could perhaps be more livestock but less confined livestock; livestock may switch from being fattened in the High Plains to being grass fed in the South. For another example, more land in the arid High Plains may move out of irrigated crop land to dry land agriculture or go out of agriculture altogether. Areas that cannot easily raise livestock or legumes would be handicapped by widespread adoption of non-conventional agriculture practices. The South might be at a disadvantage with respect to crop production without pesticides because the warmer southern climate is more hospitable to pests.

One can anticipate more land in agriculture whether or not there is a yield penalty and equivalent higher land prices (Crosson and Ekey, 1988; Cacek and Langner, 1986; Olson et al., 1982). That is, since it appears likely that much of non-conventional agricultural production will incorporate green manure crops into rotations, then even if yield per acre for a specific crop remains the same as with conventional agriculture, revenue per acre of rotation will decline. More land will therefore have to be brought into production to maintain output levels. However, research could be applied to removing any revenue penalty associated with the rotations used in non-conventional agriculture.

More agricultural labor will probably be needed with widespread adoption of non-conventional agriculture. If so, higher wages should result; such high wages may be good for rural communities, assuming they have an excess labor supply (Heffernan, 1986). But this labor force is going to need some investment in management skills, and these investments are not free. Their costs need to be taken into account when analyzing impacts (Carlson, 1988).

What about other impacts: on suppliers, on trade, and on the environment? If the goal of non-conventional agriculture is to reduce purchased inputs, one would presumably expect to see purchased input suppliers put at a disadvantage by widespread adoption. However, that may not be so. There are substitution possibilities for suppliers as well as for producers. Suppliers may find themselves transporting such nutrients as poultry litter from one part of a state to another, supplying legume seeds, providing different machinery, insect-resistant plants, beneficial insects, information and management services, or similar inputs for the non-conventional agriculture producer. The costs of such substitutions are not known, partly because the new crops and enterprise mixes are also not known. But there is no particular reason to believe that widespread adoption of non-conventional agricultural practices would be disastrous to input suppliers, except perhaps for exceptionally specialized firms. A slower rate of adoption of non-conventional agricultural practices would give suppliers a longer period in which to make adjustments in their operations in order to take advantage of substitution possibilities. With a more rapid rate of adoption, existing suppliers would be less likely to be able to make adjustments to their operations and would be more likely to be replaced by new firms serving the needs of non-conventional agricultural producers.

If higher food and fiber prices did result from widespread adoption of non-conventional agriculture (particularly for pesticide-dependent products), these higher prices would be experienced by foreign purchasers of U.S. food products and livestock feed products as well as by domestic buyers. Thus, trade exports should decline, at least in the short run. There should also be a reaction on t part of overseas competitors with U farmers to increase their agricultu production, and U.S. farmers mig need import barriers to protect th higher farm income. Of course, premiu prices, which organic agricultural pro ucts often currently receive, would n exist if there were many suppliers these products. For example, unless d mand continued to increase indefinite for organic products, in time, the supp of these products could increase suf ciently to lower their price.

The environmental benefits fro widespread adoption of non-conve tional agriculture may be great, althou some question this conclusion (Cross and Ekey, 1988). For example, nitra contamination of ground water can caused by livestock-produced (organ as well as commercial fertilizer (inc ganic) sources of nitrogen, although pr sumably a farmer of a well-manag non-conventional farm should not allo much nitrogen leakage from the cro ping system. Or, if increased tillage used to control weeds, that increa could lead to increased soil erosion. truth, there are virtually no credible da on the magnitude of these environmen benefits (Cacek and Langner, 1986).

What about the impact on the du istic nature of agriculture or the high integrated structure of agricultu After all, we have over 80 percent of o seed crops, 85 percent of our process vegetables, and 90 percent of our broil under contractual agreement (Hars barger and Stahl, 1974). Will this se of arrangement change? Will farm firm concentrations decrease? There no obvious reason that they shou There are economies of scale that co from size and integrated control. The economies may be diminished som what, but probably not much, by wid spread non-conventional agricultu adoption. Unless non-conventional pra tices require higher management ski that favor small farms, it is difficult see why the current structure of ag culture should be heavily affected.

As Buttel and Gertler (1982) note, t agricultural policies that we tend to i dict as the reason for our current co centrated agricultural sector actual

only accelerated the pace of structural change; they did not alter it. Cochrane (1979) notes "that the demise of the small farmer, mechanization, and utilization of petro-chemical inputs, were all apparent by the 1920s, before the agricultural policies were put in place." Flora and Flora (1989) elaborate: "the economic rationale for mechanization was apparent...[as early as] the 1920s." There also are studies that have reinforced the view that non-conventional agricultural farmers are not particularly associated with any particular farm size and that there are no particular inherent diseconomies of scale and size in non-conventional agriculture (Lockeretz, et al., 1981). Today there are large-scale, highly mechanized organic farms as well as small-scale, labor-intensive organic farms (Taylor, 1989). As Libby (1985) succinctly states, "there are no technological imperatives with ...[low-input] agriculture."

Summary and conclusions

The differences between conventional agriculture and alternative agriculture span a continuum of farming practices - from conventional through low-input to organic. Similarly, the beliefs which condition the attitudes of proponents of systems toward the range of practices also are a continuum (perhaps with some discrete "breaks") - from the technocratic philosophy of some conventional agriculture proponents to the more ecocentric philosophy of proponents of holistic alternative agriculture. The existence of these two continuums influences conclusions as to potential adoption rates of low-input or alternative agricultural systems as well as impacts of wide-scale adoption.

Current adoption rates of low-input practices have been influenced by an economic bias toward inexpensive fertilizers, low prices for certain farm program commodity products, and preferential treatment of farmers as polluters. This bias favors conventional practices. If policies were changed, and/or if price ratios favored low-input practices, more farmers would adopt more of these practices.

However, some goals of some proponents of alternative agriculture - specifically, a rural renaissance and revitalization of the family farm - are probably not obtainable simply as a result of widespread adoption of low-input agriculture. To achieve goals such as rural revitalization will require other actions. Indeed, rural revitalization, regional self-sufficiency, and the restructuring of agriculture could probably be achieved within a conventional system of high petrochemically based input use if society so desires. More than altering the nature of input use will be required to achieve these goals.

Thus, in the near term, it may well be that the choice of non-conventional agriculture advocates is either to promote a fundamentally different set of values regarding agriculture as a whole in the entire economic system or to work for more tangible goals within the prevailing value system (Lockeretz, 1986). Pursuing tangible goals within the prevailing system suggests the need not only for separate policies to achieve separate goals, but also the need to improve the options and choices available to farmers. Such improvement could include the redesign of policies that are barriers to this wider range of choice.

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Oklahoma passes organic food law

A law providing a legal definition for the term "organic" and setting up a state certification process has been passed by the Oklahoma state legislature. To qualify as a certified organic producer, a farmer must not have used restricted substances within the past three years, must maintain buffer zones between organic and conventional production areas, and have soils that show no evidence of pesticide residue. For information, contact Nancy Loveless, Oklahoma Department of Agriculture, 2800 North Lincoln Boulevard, Oklahoma City, OK 73105-4298.

Federal programs favor heavy fertilizer use

Because they favor the planting of continuous corn, federal farm programs also favor the heavy use of fertilizers necessary in that monocrop system, says an Iowa State University study. ISU Extension Service economist Michael Duffy compared the benefits given to six different corn rotation systems by the 1985 Food Security Act. He found that most benefits go to continuous corn farmers and that rotations with oats and hay - systems that rely less on commercial fertilizers - receive the lowest subsidies.

In 1989 subsidies, the continuous corn farmer received $69 per acre, and the farmer with a corn-oats-meadow-meadow rotation received $19. Without the government program, a corn-soybean rotation would be the most profitable, while a continuous corn rotation would have the lowest returns, Duffy concluded. For more information, contact the Extension News, Iowa State University, 103 Morrill Hall, Ames, IA 50011.

Policy barriers to sustainable agriculture

Douglas L. Young

Abstract. *U.S. agriculture, which has developed in a mixed environment of private initiative and government support, is very successful by many measures. American farmers produce record levels of food and fiber per farm worker at very low budgetary cost to consumers. Recently, however, concern about resource depletion and agrichemical pollution has caused critics to question the environmental sustainability of the agricultural production system. Furthermore, pressures to trim the growing contribution of agricultural subsidies to the national budget deficit have led legislators and others to question the sustainability of the federal farm programs. Low agrichemical input or sustainable agricultural practices, such as nitrogen-fixing legumes in rotation with cereals, could reduce environmental damage. The selectivity and structure of historical farm programs, however, have economically favored conventional systems. Farm programs subsidize only about half the total value of agricultural products. Feed and food grains, cotton, and dairy products receive the lion's share of payments. Soil-building crops like forage legumes, most edible legumes, hay, and pasture are excluded. Secondly, the structure of commodity programs favors intensive production of program crops supported by high fertilizer and pesticide applications. This incentive emanates from the policy of computing the farm-wide deficiency payment for a program crop proportionately to the farm's historical "base" acreage and "established" yield for the crop. The leading farm program crops of corn, wheat, cotton, and soybeans occupied slightly over 60 percent of cropped acres and received at least 65 percent of all U.S. agricultural pesticides and fertilizer in the mid 1980's. Despite budget pressures and environmental concerns, near term termination of farm programs or decoupling them from production of particular commodities is unlikely. Fears about aggravating financial stress, reducing land values, and harming agrichemical supply businesses in program crop-growing regions will promote cautious incremental change. Recent promising signs of "creeping decoupling" include the 1986 freeze on established yields, the gradual reduction in target prices, the permitting of multi-year grass or legume plantings as set aside acreage, and the loosening of base acreage restrictions within the 1988 Drought Relief Bill.*

Key words: agricultural policy, sustainable agriculture, commodity programs, low-input agriculture, decoupling

Introduction

By most commonly accepted measures, modern U.S. agriculture is extremely productive. Each farm worker produces record levels of food and fiber at very low budgetary cost to consumers. Nonetheless, charges have been increasing that this agricultural system is ecologically and politically unsustainable. The former charge relates to socially unacceptable damage inflicted on soil, water, wildlife, and other natural resources by the intensive use of agrichemicals and tillage. Secondly, pressures to control the unprecedented growth in the federal deficit threaten to reduce annual public subsidies to agriculture. These peaked at $26 billion in 1986-87 and are estimated at 22 and 13 billion dollars for the following two fiscal years despite the relatively healthy current agricultural economy (USDA, 1989).

The ecological and fiscal problems described above are related. This paper will attempt to show that the structure of U.S. farm programs has not only contributed to high taxpayer costs and failed to curtail surpluses, but has also encouraged intensive cultivation of chemical-intensive crops. While improvements have recently been made, commodity policies remain a severe constraint to low agrichemical input or sustainable agriculture, which a recent Congressional report declared to "...hold great promise for preventing groundwater contamination and reducing farmers' costs by minimizing or eliminating pesticide and fertilizer use" (House of Representatives, 1988).

The objectives of this paper will be: 1) to describe the mechanisms by which United States farm commodity programs encourage conventional farming systems and discourage low-input systems, 2) to review empirical evidence on the impact of past commodity programs on cropping patterns and agrichemical use, 3) to review in broad terms some positive and negative impacts of reforming or terminating current commodity programs, and 4) to discuss promising recent, and potential future, changes in government farm programs as they affect incentives for low-input agriculture.

How commodity programs favor conventional agriculture: Theory and evidence

Not all commodities receive subsidies

Since their inception during the Great

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Depression, commodity programs have influenced the output mix and input use patterns of American agriculture through both their selectivity and their structure. Although the press sometimes gives the impression that all farmers receive subsidies, payments are restricted to specified agricultural products. Of the $148 billion average gross market value of U.S. crop and livestock production during 1980-85, only 51 percent was included in commodity programs (USDA, 1987). Corn and other feed grains, wheat, rice, cotton, soybeans, sugar, peanuts, wool, tobacco, and dairy products account for nearly all government farm subsidies (Womach, 1988). USDA (1988) estimated that 52 percent of 1986 farm subsidies went to corn and other grains, 28 percent to dairy, 3 percent to soybeans, and 17 percent to other supported commodities. Many farmers and ranchers never receive a government subsidy check. Growers outside the government circle include beef ranchers, hog producers, hay growers, potato farmers, egg and broiler growers, vegetable producers, and fruit orchardists, among others. Of course, government farm programs indirectly affect producers of non-supported commodities through market interactions. For example, feed grain programs which lead to surplus corn production can reduce feed costs for livestock feeders.

Microeconomic theory predicts that increasing the relative profitability of selected program crops will direct land and other resources to these crops at the expense of non-program crops. Land that might be used to produce vegetables will be used for corn or cotton instead. Wheat or barley that might be produced in rotation with forage legumes are produced in intensive rotations supported by high fertilizer and pesticide applications. Land that might otherwise be producing beef cattle is used for dairying.

Empirically, it is very difficult to disentangle the contribution of commodity programs alone to the growth in base acreage of major program crops such as corn, wheat, and cotton. Changes in relative prices driven by changing technology and other factors also contribute powerfully to these acreage shifts. Planted plus set aside acreage devoted to corn, cotton, and wheat rose from historic levels of 40-50 percent to over 50 percent of U.S. cropland during both the late 1960's and mid-1980's when large surpluses depressed crop prices and created strong incentives for program participation (USDA, 1987). Many might consider 50 percent of total cropland a high fraction for these three program crops which have often accumulated large surpluses in excess of demand.

Payments are based on historical production of program crops

The structure of farm support programs varies considerably from commodity to commodity. Tobacco and sugar programs, for example, rely strongly on acreage and import quotas, respectively, which transfer program costs to consumers. Government purchases of surplus manufactured dairy products support the price of fluid milk. Soybeans receive downside price protection with "non-recourse loans" but do not qualify for supplemental deficiency payments like grains and cotton.

The feed and food grain and cotton programs, which typically absorb the lion's share of taxpayer dollars, support income of participating farmers with "non-recourse loans" and "deficiency payments." Participants must withdraw (set aside) from production a specified fraction of their "base acreage" of a program crop. Participating growers may "loan" their crop to the government for the loan rate "floor price" at harvest. If market prices later exceed the loan rate, the grower may repay the loan and sell the crop on the market. If the market price remains below the loan rate, the grower may forfeit the crop to the government and keep the loan proceeds. The protection from downside price movements provided by non-recourse loans can make program crops more attractive.

A participating farmer's annual deficiency payment, subject to the $50,000 per farm limitation, equals the "deficiency payment per bushel" times the farm's "established yield" for the crop times the number of "base acres" in that crop net of any set aside acreage. The deficiency payment per bushel is equ to the difference between the legislate target price and the loan rate or avera market price, whichever of the latter tw is higher.

The individual farmer has no contr over the deficiency payment per bushe which is determined jointly by Congre and the market. The farmer has had co siderable long-run control, howeve over his established yield and ba acreage. These quantities have bee computed as moving averages of th farm's past yields and acreages in th crop. The 1985 Farm Bill precluded fu ther increases in established yields b freezing these at 1986 levels. Farme may still expand base acreages by i creasing plantings of program crops du ing years they elect not to participate i the programs. Increasing future def ciency payments by expanding progra crop base acreage can pay off for sever years. Also, these increases in farm i come are immune to short-run fluctu tions in weather and market prices. If drought cuts a participating farmer yields in half, the farmer's deficienc payment check for that year based upo established yield and acreage is not a fected.

The dependence of future governme payments on maintaining high progra crop acreage can serve as a major barri to introducing sustainable rotation Monoculture corn growers will be r luctant to shift to rotations includi oats and green manures even if hig market prices for oats and nitrogen, an low market prices for corn, make seemingly profitable in the short ru They fear losing valuable corn base i the long run and attractive corn def ciency payments in the short run. Co sequently, they may continue adding t surplus corn production despite co trary market signals.

The inter-commodity cross-compl ance provision in the 1985 Farm Bi added another restriction to farmer flexibility in changing crop rotation This provision restricts farmers withi their base acreage on other progra crops if they are participating for an program crop(s). Consequently, a mo oculture corn grower with no wheat bas who wishes to add wheat in a rotatio

cannot do so without losing eligibility for the profitable corn program.

As government programs encourage program crops, farmers might not only substitute program crops onto land that previously grew non-program crops but continue to grow program crops on the same land in more intensive rotations supported by higher fertilization and pesticide applications. Weeds and diseases flourish in cereal-intensive rotations because the pest has uninterrupted access to the susceptible host plant (Cook, 1986). Higher pesticide rates are required to sustain crop health.

Do farm programs increase agrichemical use?

By tilting U.S. agricultural production toward feed grains, food grains, and cotton, USDA commodity programs substantially boost agrichemical use because these crops are heavy consumers of pesticides and fertilizers. Fleming (1987) reported that the Big Four program crops of corn, cotton, soybeans, and wheat received at least 65 percent of total agricultural pesticides and fertilizer. These same four crops accounted for 61 percent of cropland used for crops in 1986 (USDA, 1987). Fleming cited further estimates that more than half of herbicides applied to field crops are devoted to corn alone and that herbicides represent 85 percent of all pesticide use. Vrooman (1987) reported that the share of total U.S. nitrogen, phosphate, and potash use devoted to corn, cotton, wheat, and soybeans grew from 42 percent in 1964 to 62 percent in 1985. Hallberg (1986) reported data from the Corn Belt showing that average applications of nitrogen fertilizer on corn grew from 65 lbs/ac in 1965 to 135 lbs/ac in 1982. While many non-program vegetable and fruit crops also receive high agrichemical applications, acreages of these crops are small compared to those of major program crops. Reichelderfer (1985) concluded that program crops are also more soil eroding than non-program crops.

Daberkow and Reichelderfer (1988) have questioned whether the historical moving average basis for established yields caused farmers to use more fertilizer and pesticides in order to capture greater future deficiency payments. The theoretical basis for this incentive is clear, however, as shown by the derivation presented in the Appendix. The derivation shows that incorporating expectations of future deficiency payments under pre-1986 regulations will inflate input use by an amount positively proportional to expected future deficiency payments. These input-boosting incentives operated for feed and food grains for over two decades between 1964 and 1986. Until 1964, farm programs were primarily based upon acreage allotments, loan rates, and paid land diversion (Blakeslee, 1980; Cochrane and Ryan, 1976). Direct payments which were introduced in 1964, and deficiency payments, which began in 1971, were both tied to historical yields and thereby introduced incentives to boost yields through greater input use in order to capture higher future payments. Established yield provisions may have substantially increased fertilizer and pesticide application rates during the two decades they were in place, but additional empirical work on this issue is needed (Young, 1988).

The simple static model presented in the Appendix, which relates established yield provisions to input use incentives, abstracts from the dynamics of adjustment and the pervasive uncertainty regarding key variables. High farmer discount rates due to short time horizons or uncertainty could also dampen the effects of future deficiency payment expectations. However, it seems reasonable that a deterministic dynamic model with constant expectations might converge to similar results.

Past economic analyses have often explained changes in output mixes and input use rates as responses to changes in market prices only. A more complete understanding requires incorporating commodity program effects. During much of the recent period, when many farmers received substantial deficiency payments for corn, there is strong reason to believe that the ammonia price/corn loan rate ratio cited by Daberkow and Reichelderfer (1988) did not fully capture the incentives for nitrogen fertilizer use in corn. Nitrogen applications reported by these researchers averaged 112 and 105 lbs/ac in 1970 and 1975, but moved sharply upward to 130-140 lbs/ac in the 1980's despite an upward trend in the nitrogen price/corn loan rate ratio. Technical change, better information, and possibly other factors could explain part of this growth in nitrogen use. Another candidate, however, is the incentive to boost future deficiency payments by increasing established yields.

Some important exceptions and caveats

While the selectivity and structure of the commodity programs impart a high-input bias, it should be noted that not all farm programs encourage intensive farming systems. Payments for long-term land retirement programs, such as the 1950's "soil bank" and today's Conservation Reserve Program, are not linked to base acreages and yields and therefore do not directly favor input-intensive crops.

Whether low-input systems will be competitive with current conventional systems without farm programs will vary by region and by commodity. Obviously, some non-subsidized commodities, including many fruits and vegetables, appear to be most profitably produced by very chemical-intensive systems, even in the absence of subsidies. The same applies for livestock feeding operations which have come under fire for heavy use of chemical implants and antibiotics. Also, set aside provisions associated with participation in the feed and food grain programs can sometimes work to the advantage of low-input growers who find set aside a profitable use of their green manure or forage legume acreage (Dobbs et al., 1988).

Several studies have been completed which show that organic or low-input farms can be as profitable, or more profitable, than their conventional counterparts in certain situations (see Hodges, 1978; Cacek and Langner, 1986; and Vogtmann, 1984; for summaries of several comparative studies in North America and Europe). Nonetheless, the overwhelming majority of U.S. farms continue to use conventional practices which rely heavily on agrichemical inputs. A negligible proportion of total

U.S. food and fiber is produced by genuinely organic methods. Considering the claims in the sustainable agriculture literature of the profitability of low-input methods in case study comparisons, a reader might legitimately wonder why low-input systems are not more common. The arguments presented above suggest that the answer, in part, is related to the structure of U.S. farm commodity policies. However, agrichemical intensification incentives also hinge critically on the supply-demand balance which drives commodity and input prices. During periods of relatively strong demand, high-market prices for program crops can provide many of the same incentives for intensive fertilizer and pesticide use as do commodity programs in other periods. For example, comparisons by Goldstein and Young (1987) revealed that a conventional grain-intensive rotation acquired a profit advantage over a low-input legume-wheat rotation whenever market wheat prices exceeded $3.50/bu.

The observation that market-driven price increases for grains and other program crops can motivate occasional intensive use of land and agrichemical inputs does not negate the argument for avoiding excessive use of these inputs by removing policy biases. Indeed, it reinforces arguments for conserving our land, water, and pollution absorption capacities for periods of real economic need.

Aggregate economic impacts of terminating or decoupling farm programs

To promote the environmental and fiscal benefits of wide-scale adoption of low-input agriculture, some economists and legislators have advocated "decoupling" all U.S. farm subsidies from production. This would permit "targeting" payments to particular types of growers, for example, to "family farmers" or to farmers using environmentally safe practices. Decoupling would make commodity programs neutral with respect to the choice between low-input and conventional production systems. Historically, however, American farmers have resisted decoupled direct payments. Such payments smack of welfare and shatter the argument that the subsidies have been "earned."

Given the substantial adjustment problems which would be associated with sudden termination of agricultural programs, some form of phased reduction or decoupling is more likely. Decoupling payments from selected commodities would weaken incentives for high chemical input production of those crops but would not necessarily reduce taxpayer costs if retargeted transfer payments remained high.

An even more extreme policy proposal was advanced by the Reagan Administration. On July 6, 1987, in Geneva, Switzerland, the Administration proposed at a meeting of the 93-country General Agreement on Tariffs and Trade that all farm subsidies in the world be terminated as part of a multilateral program by the turn of the century. While the long-run U.S. goal has remained essentially fixed, there has been no rush by other countries with major agricultural support programs, most notably the EEC, to endorse this proposal. However, the proposal does legitimize termination as an option for public debate. Willard Cochrane (1986), an eminent agricultural economist and long-time architect of government farm programs, has also recommended immediate termination. There are occasional reports in the popular press of farmers themselves who wish to get "off the public dole." In part, this grass roots sentiment seems to be founded in the belief that the long-run competitive strength of U.S. agriculture would be served by foregoing subsidies:

In the Midwest it is now coffee shop gospel that, despite fifty years of government assistance, farmers producing subsidized commodities lag behind livestock raisers, vegetable growers, and others who fend for themselves in the marketplace (Newsweek, 1987).

However, farmers who would actually vote to eliminate farm programs are probably a minority. Even those who speak out against farm programs presumably keep their federal checks and, if pushed, would probably condition their preference for a free market by requiring other governments to play by t same rules.

Although farm commodity progra can be criticized on equity groun ("Why should corn growers receive su sidies if cherry growers and plumbers not?"), the central economic defect these programs is their inefficiency. basic tenet of economics is that gover ment intervention, in the absence market failure, is less efficient than le ting the free market allocate resource In the case of farm subsidies, this mea that the total dollar losses of taxpaye exceed the monetary benefits to produ ers and consumers.

Despite the economic efficiency a gument for terminating governme farm subsidies, most agricultural eco omists and politicians resist terminatio and focus their attention on the sub stantial adjustment costs it would im pose. A recent study by a cross-sectio of agricultural policy specialists (Wa lace, 1987) concluded:.

Highly leveraged farms would sta virtually no chance of remaining solve for the next ten years in the absence farm programs. Because one-third U.S. farmers are considered to be high leveraged, even a transition policy phase out farm price and income suppo would likely cause rapidly falling la values, accelerated structural chang and added stress on the agricultural nancial sector.

Producers of non-supported produc would also be affected as some gra growers, sugar producers, dairyme and other program commodity produ ers shifted to traditionally non-su ported commodities. In addition to t adjustments mentioned by Wallac agrichemical and machinery supplie would likely face reductions in dema as U.S. output of chemical-intensi crops shrank and production practic changed after terminating farm sub dies. Employment and income in ag business would fall accordingly. The concerns probably underlie the rece opposition by the fertilizer industry USDA's low-input sustainable agricu ture program (House of Representativ 1988).

Although microeconomic budgeti comparisons of conventional and lo

input systems under "no commodity policies" scenarios fail to capture all endogenous price adjustments that would in fact be realized, they indicate just how sharply incomes could fall for both conventional and low-input producers in the absence of farm programs. Goldstein and Young (1987) presented such a comparison for a cereal-intensive conventional system and a low-input legume-cereal rotation under the depressed agricultural economy of the mid-1980's. The low-input rotation became relatively more profitable than the conventional rotation without commodity programs, but net returns for the low-input rotation were only 54 percent of what they would have been with taxpayer subsidies. Comparisons by Dobbs et al. (1988) for conventional versus low-input cropping systems in the Northern Plains showed similar results. Taxpayer savings with a complete termination of farm programs will be accompanied by income losses for producers of program crops. Indirectly, other producers and consumers will be affected through changes in land use and in food prices.

In addition to the more easily quantified market gains and losses shared by taxpayers, producers, and consumers, there would be substantial non-market environmental benefits and losses from commodity program termination. Studies by Dixon et al. (1973) and by Miranowski (1975), while dated, provide estimates of the substantial environmental benefits. Dixon et al. estimated that least-cost free market production during 1965 could have satisfied output demands with one-half of the agrichemical use observed under prevailing government policies.

Overall, the most effective argument for retaining current commodity programs is that they promote social welfare by stabilizing prices for farmers and building buffer stocks against food crises (Womach, 1988). It is likely that world corn prices would have escalated considerably more in 1988 if U.S. feed grain policy had not built such large American stocks of corn. While defensible arguments can be made for some degree of price stabilization and maintenance of strategic grain reserves, it is not at all clear that the current system is the most cost effective (Hertel, 1988). With the enormous growth in on-farm storage in the U.S., use of storage subsidies and incentive payments should be able to ensure adequate farmer or government-owned reserves without the current policy structure.

Hertel (1988) recently modeled the national efficiency and distributional performance of the current farm program and three production quota alternatives, but he did not include decoupling. Hertel's results showed the current program sharply increased the demand for fertilizer and other off-farm inputs. It was also the most costly to taxpayers and imposed the greatest national welfare loss of the four alternatives examined.

Decoupling of farm subsidies to promote environmental and efficiency objectives will also impose differential benefits and costs by region and by commodity group. How much will market prices of corn and barley change as planted acreage of these crops changes in the absence of government acreage restrictions and target price protection? How will feed grain price changes affect the income of cattle and hog feeders? Will pasture and hay prices fall as more marginal program crop land goes into these uses? How will these adjustments affect western ranchers?

Non-market and dynamic benefits of decoupling may be more important than the various market effects discussed above. Historically high target prices for selected commodities together with water and energy pricing policies have motivated utilization of energy, topsoil, groundwater, and other resources beyond the economically optimal rates indicated by market prices. Letting the market determine resource depletion rates would have conserved greater supplies of these resources for future generations.

Agricultural policy also has an important impact on the long-run international competitive position of U.S. agriculture. Increasing evidence indicates that the United States no longer enjoys a competitive cost advantage over some of its major competitors (Doane's Agricultural Report, 1986; Ortmann et al., 1986). Nevertheless, some analysts (Wallace, 1987) are pessimistic about the capacity of terminating U.S. farm programs to improve our international trade position. However, it is possible a continuation of the current protected position could harm the long-run competitiveness of U.S. producers. As U.S. producers remain insulated from market forces, the gap between domestic and competitive world market production costs that would have to be picked up by taxpayers could grow beyond acceptable bounds.

New Zealand abruptly instituted a free market policy in 1984 after the costs of subsidies and grants became unaffordable (Johnston and Sandrey, 1989). The adjustment process has been painful for New Zealand's farmers and ranchers due to adverse weather and recent macroeconomic trends as well as to the sharp reduction in government support. A less abrupt transition would likely have cushioned adjustment problems, but only more time will determine the final outcome.

Some of the countries providing the U.S. its toughest agricultural export competition, such as Australia and Argentina, have reduced production costs for grains by using low-input livestock-forage-grain rotations which make sparing use of fertilizer and other agricultural inputs (Ortmann et al., 1986; personal communication, Albert Rovira, 1987).

U.S. agricultural policy also influences global economic and political stability. Expensive farm subsidy programs in the United States, the EEC, and other developed countries depress world agricultural prices and discourage agricultural development and food self-sufficiency in less-developed countries (Schuh, 1986). Schuh has argued that aiding agricultural development in LDC's promotes the long-run economic interests of the U.S. and other developed countries. The long-run capacity of LDC's to trade with the U.S. for mutual gain is based upon purchasing power, not need.

Recent changes: Creeping decoupling

The new conservation reserve, con-

servation compliance, sodbuster, and swampbuster provisions made the 1985 Farm Bill a landmark in soil conservation legislation. Reforms in the commodity program provisions were more modest with respect to their potential for improving environmental quality, but some progress was made. The most significant change was the freeze on established yields at 1986 levels. This eliminated the incentive to apply additional pesticides and fertilizer in order to boost future deficiency payments. The selective bias toward chemical-input-intensive program crops was modestly slowed by scheduling a gradual decrease in target prices. The target price of wheat, for example, was scheduled to decline gradually from $4.38/bu in 1986 to $4.00/bu in 1990. Mandatory Gramm-Rudman expenditure restrictions reduced actual target prices slightly below the scheduled levels in some years.

The 1985 legislation also introduced greater flexibility in acreage set aside regulations. For example, growers in some areas were permitted to use multiple-year grass or forage legume plantings as set aside. As long as these plantings were designated as set aside, they were not subtracted from the farmer's base acreage. However, the reduction in set aside rates from 27.5 percent to 10 percent for wheat and from 20 percent to 10 percent for feed grains in 1989 could induce growers with excess grass/legume plantings to plow up some of these soil-conserving cover crops.

Benbrook (1988a) has called attention to a favorable feature of the 1988 Drought Relief Bill. It permits planting soybeans and oats in 1989 and 1990 on part of a grower's wheat or corn base acreage without losing base. The modest steps taken in the 1988 Drought Relief Bill and in the 1985 Farm Bill might be characterized as "creeping decoupling." While this pattern represents a step in the right direction, the base acreage system and the selective nature of the programs continue to impose severe restrictions on farmers' flexibility in altering rotations.

Prospects for change in the 1990 Farm Bill and beyond

A combination of environmental and fiscal pressures appears to be forging a consensus both outside and inside government which will enable the creeping decoupling begun in 1985 to continue in the 1990 Farm Bill (House of Representatives, 1988; Benbrook, 1988a; de la Garza, 1988). House Majority Leader Tom Foley has warned that budgetary pressures would likely limit farm program expenditures to as little as $10 billion per year in the next Farm Bill, some $7 billion less than the average outlays per year over the past seven years (Hammer, 1988). This reduction stands in contrast to a record expenditure of $25.8 billion in 1986. Aided substantially by the recovering farm economy, the drought, and current budget-reduction provisions, expenditures are projected to decline to $12.2 billion in fiscal 1990 (de la Garza, 1988). The Chairman of the House Agricultural Committee has stated that the 1990 Farm Bill must consider reforming "...the rigid and confining nature of the current crop-specific base system...flexibility should be a major objective of the next Farm Bill...[the current base system] discourages the crop rotation methods that are the foundation of sound conservation practices" (de la Garza, 1988). Chairman de la Garza proposes, as a compromise, returning to a version of the somewhat more flexible normal crop acreage (NCA) system that was used prior to 1981.

Analysts within USDA have also recognized the linkage between current commodity programs and low-input agriculture and its associated environmental benefits (Daberkow and Reichelderfer, 1988):

...removal or modification of commodity program incentives would likely have the most dramatic short-term influence on the feasibility of LIA [low-input agriculture] systems. Empirical studies suggest that targeted output reduction or decoupling strategies could reduce the demand for agrichemicals. The magnitude of potential reduction, however, is uncertain.

A recent report by the Environment, Energy, and Natural Resources Subcommittee (House of Representatives, 1988) argued that "Congress should explore and adopt incentives that will eli
inate the existing statutorily-bas
barriers to low-input farming system
in designing the 1990 Farm Bill. T
Subcommittee places major blame
the inflexible base acreage provisions
roadblocks to low-input agriculture a
to greater use of cropping rotations.

Demands for reform have also be
aimed at the sugar program in whi
price protection supported by imp
quotas and government loan rates ha
shifted high costs to consumers and p
tentially to taxpayers. Equity as well
efficiency considerations underlie ind
nation about the sugar program. Ha
mer (1988) reports an instance in whi
two Florida sugar growers in 1986-
accounted for "...27 percent of total U
cane sugar output and 13 percent of
U.S. sugar production. This meant
windfall of more than $250 million
these two growers in one year alone.

While the discussion in this secti
has focused on potential changes in co
modity provisions of the 1990 Farm B
which would favor incentives for lo
input agriculture, there is also a stro
movement for complementary enviro
mental legislation. Benbrook (1988
has written that "The most pressing e
vironmental objective for the 1990 Far
Bill will be to do for water quality pr
tection what the 1985 Farm Bill did f
soil erosion control." Some sort of ag
chemical compliance, similar to the 19
conservation compliance legislation, w
likely be considered.

The total decoupling of commodi
programs is likely to be too large a d
parture from existing policy to attra
support from policymakers and burea
crats more comfortable with increment
change. Decoupling is sure to encount
resistance from program commodity i
terest groups such as corn growers, co
ton producers, and others who ha
benefited under the old sytem. Non-pr
gram crop growers are also likely to r
sist decoupling out of concern abo
increased supply competition from acr
released from program crops. From t
general public interest, however, it is d
ficult to escape the compelling ef
ciency, equity, and environmen
arguments favoring decoupling. It p
mits markets to determine cropping p

terns and allocation of resources. Markets are likely to provide better signals for current resource allocation, the direction of future technical change, and response to changing international competition than the combination of historical tradition and current political power which fashions farm programs. Furthermore, by decoupling and retargeting, taxpayer transfers to agriculture can be explicitly targeted to meet environmental and social goals. This two-stage process should help eliminate some of the conflicts between commodity and conservation programs which have frustrated achievement of environmental goals in the past.

As Congress moves away from the current system of payments tied to selected commodities, some will argue for a simple termination of all farm programs as in the Reagan and Bush administrations' GATT proposals. Given the realities of international competition and the pervasive influence of environmental and social externalities in agriculture, outright termination could adversely impact social welfare. For example, the social and community benefits of preserving a sizeable rural farming population might justify transfers to "family-sized farms." Similarly, public intervention to regulate agrichemical use and other environmentally sensitive practices will likely be necessary in order to abate pollution to socially optimal levels, even in a world of decoupled or terminated agricultural subsidies.

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APPENDIX

Impact of Pre-1986 Established Yield Provision on Input Use Incentives

Let expression (1) represent a static current-period objective function for a farmer first confronting input choices in the presence of deficiency payments:

$$(1) \qquad \pi = P_t Y_t(X_t) - C(X_t) - FC + \overline{Y}_t(T_t - P_t) + \sum_{j=1}^{5} \frac{\left(\sum_{i=0}^{4} Y_{t+j-5+i}/5 - \overline{Y}_t\right)(T_{t+j} - P_{t+j})}{(1+r)^j}$$

π = net returns per acre for the program crop, considering both current-year returns and the present value of *increases* in future deficiency payments attributable to current-year yield, Y_t

P_t = the expected market price or loan rate for the crop, whichever is higher

$Y_t(X_t)$ = the yield as a function of agrichemical input(s), X_t

$C(X_t)$ = the total cost of agrichemical input(s)

FC = assumed fixed cost for all other inputs for this short-run case

$\overline{Y}_t$ = established farm yield in year t for the program crop, based upon previous cropping history, assumed equal to profit maximizing yield in absence of farm programs. $\overline{Y}_t$ also equals established yield in successive years if no adjustment in input use is made to incorporate the influence of deficiency payments

T_t = announced target price in year t

$Y_{t+j-5+i}$ = yield in each of the indexed years

$\sum_{i=0}^{4} Y_{t+j-5+i}/5$ = established farm yield in successive years; the simple 5-year average abstracts from USDA's practice of throwing out the low and high years in computing this average

T_{t+j} = expected target price in year $t + j$

P_{t+j} = expected market (loan) price in year $t + j$

r = farmer's discount rate.

The terms on the right-hand side of the equal sign in (1) represent the gross returns from crop sales in the current year, total agrichemical costs, all other costs (assumed fixed), current year deficiency payment and the present value of increases in deficiency payments over the next five years as a result of the influence of the current year's yield on future established yields.

Expression (2) presents the first order condition for maximizing (1) with respect to X_t under the simplifying assumption (which ignore the dynamics of adjustment) that farmers' expectations of all past and future yields, except Y_t, remain at $\overline{Y}_t$ in computing established farm yields in future years:

$$(2) \qquad \partial\pi/\partial X_t = P_t MPP(X_t) - MFC(X_t) + \sum_{j=1}^{5} \frac{MPP(X_t)/5}{(1+r)^j} \cdot (T_{t+j} - P_{t+j}) = 0$$

MPP = the marginal physical product of X_t

MFC = the marginal factor cost of X_t.

Assuming a zero discount rate and further assuming future target and market (loan) price expectations equal to current year levels, expression (2) reduces to equation (3):

(3) $$T_i\, MPP(X_i) = MFC(X_i)$$

In other words, the current year profit maximizing level of agrichemical use requires equating the marginal value product *based on the target price* to the current year price of the agrichemical. Consequently, consideration of deficiency payments generated by target prices in excess of maket prices could theoretically move input applications considerably above levels justified by market (loan) prices alone.

Relaxing the simplifying zero discount rate assumption dampens slightly the incentive to apply inputs at levels justified by market prices alone, but does not reverse its direction. Equation (2) implies that positive discount rates will motivate profit maximizing input applications consistent with output prices between market and target levels. Profit maximizing input applications will vary inversely with the discount rate, but will considerably exceed those consistent with single year market prices alone for most commonly accepted discount rates. In practice, uncertainty about future target and market prices is probably a more important limitation to the simple decision model above than are positive discount rates.

UPCOMING EVENTS

May 8-16. Action for a Common Future, sponsored by the World Commission on Environment and Development, in Bergen, Norway. The conference will develop an agenda for action on the UN report *Our Common Future*. Contact Ms. Fran Spivy-Weber, National Audubon Society, 801 Pennsylvania Avenue, SE, Washington, DC 20005, (202) 547-9009.

July 9-10. Organic Meat Symposium, sponsored by the University of Minnesota Extension Service, in Minneapolis, Minnesota. Topics include regulations, production, and marketing methods. Contact Laura McCann, Center for Alternative Plant and Animal Products, 305 Alderman Hall, University of Minnesota, St. Paul, MN 55108, (612) 625-5747.

July 26. Milan No-Till Field Day, sponsored by the University of Tennessee Milan Experiment Station, in Milan, Tennessee. Contact John F. Bradley, Milan Experiment Station, 205 Ellington Drive, Milan, TN 38358, (901) 686-7362.

July 29-August 1. Soil and Water Conservation Society in Salt Lake City, Utah. The topic is "Water Futures." Contact Dr. Jan van Schilfgaarde, SWCS, 7515 NE Ankeny Road, Ankeny, IA 50021.

August 12-15. Conserv 90, a conference on water supply solutions for the 1990s sponsored by the American Water Resources Association and others, in Phoenix, Arizona. For information, contact Conserv 90, 6375 Riverside Drive, Dublin, OH 43017, (614) 761-1711.

August 15-18. National Sustainable Agriculture Forum, sponsored by the Universities of Nebraska, Iowa State, and Missouri, in Lincoln, Nebraska. Contact Jim Bushnell, Assistant Director, Institute of Agriculture and Natural Resources, University of Nebraska, 211 Agricultural Hall, Lincoln, NE 68583-0703, (401) 472-2966.

August 23-25. Fourth National Amaranth Symposium, sponsored by the Amaranth Institute, the American Society of Agronomy, and others, in Minneapolis, Minnesota. Contact Extension Special Programs, Minnesota Extension Service, University of Minnesota, 405 Coffey Hall, 1420 Eckles Avenue, St. Paul, MN 55108-1030.

August 27-30. IFOAM 8th International Conference, in Budapest, Hungary. The program will include social and economic aspects of organic agriculture, practices, marketing, and tours. Contact the Biokultura Association, IFOAM Conference Secretariat, Budapest, Arany Janos u 25, 1051, Hungary, Europe.

September 23-27. The Australian Organic Agriculture Conference, a regional conference of the International Federation of Organic Agriculture Movements, in Adelaide, South Australia. Contact Elisabeth Eaton, Conference Secretariat, Festival City Conventions, P.O. Box 986, Norwood, SA 5067, Australia; 08/269-4663.

September 26-29. International Symposium on Agroecology and Conservation Issues in Temperate and Tropical Regions, in Padova, Italy. The emphasis will be on the interrelation and transfer of research and application in sustainability and environmental problems between temperate and tropical areas of the world. For information, contact M. G. Paoletti, Department of Biology, Padova University, via Trieste, 75, 35100-Padova, Italy.

December 2-5. Midwest Fish and Wildlife Conference, in Minneapolis, Minnesota. A day-long session will address "Changing Farm Practices: Sustainable Benefits for Fish and Wildlife?" Papers and poster sessions are invited. For information on the special session, contact Ann Robinson, Izaak Walton League, 801 Commerce Drive, Decorah, IA 52101, (319) 382-2947. For information on the general conference, contact Blair Joselyn, Wildlife Research, Box 7, Minnesota Department of Natural Resources, 500 Lafayette Road, St. Paul, MN 55155-4007, (612) 296-3344.

Implications of low-input farming systems for the U.S. position in world agriculture

John E. Lee, Jr., and Kenneth Baum

Abstract. *The adoption of sustainable farming system practices by U.S. producers could affect the international competitive position of many agricultural commodities, including livestock. The adoption of such practices over the next several decades will depend on commodity policy legislation, environmental regulation, commodity price and acreage diversion incentives, and the success of ongoing GATT negotiations and trade liberalization. However, the extent and magnitude of these effects are dependent on the internalization and recognition of social costs of agricultural production by farmers and explicit tradeoffs between environmental degradation and agricultural profitability. Environmental externalities include soil loss, surface and ground water contamination by agricultural residuals, loss of wildlife habitat, and diminished aesthetic amenities. In effect, both public and private concerns about the marginal social environmental costs associated with production, when present, will influence the shape and location of commodity supply curves and the U.S. export capability. In turn, these supply curves, which define the production capacity of the U.S. to meet domestic and export demand, will determine our comparative competitive positions for different commodities in world markets.*

Key words: sustainability, environmental regulation, agricultural profitability, soil and water conservation, export capability

Introduction

The subject of low-input and sustainable farming systems is becoming increasingly important because of concerns about environmental quality, safe drinking water, conservation of soil and water resources, competitiveness of farms in a global setting, and maintenance of a viable, pluralistic rural economic and farm sector in America. The timing is right because, while this conference couldn't have been held 15 years ago, we can't wait any longer to deal with the issues relating to the sustainability of U.S. agriculture.

Addressing these complex interdisciplinary issues will require much additional study. The complicated process of developing new agricultural policies involving people with a wide range of agricultural and urban backgrounds, motivations, and interests but with common goals, will take time and engender further debate. A sustainable agriculture certainly must be economically sound for the longer run, protect and enhance the productive resource base, be consistent with society's environmental values and desires (broadly defined here to include everything from safe water to aesthetic amenities), and recognize that we live in a global economy and on a shrinking planet.

This study joins a growing dialogue about implications of low-input farming systems for the U.S. competitive positio in world agricultural markets. It ex amines some alternative policy scenario as they relate to low-input and sustain able agriculture (LISA) and the impli cations of several scenarios for U.S competitiveness in world markets.

We assume that low-input sustainabl agriculture (LISA) refers to manage ment practices and systems that mini mize environmental degradation an threats to long-term agricultural sus tainability, and that rely on less intensiv and more effective use of petro-base chemicals and less wasteful use of nat ural resources such as water and soi We do *not* assume this means low tech nology agriculture. In fact, investmen in and research leading to more intensiv management and biotechnological de velopments over the next several decade may be the keys to successful U.S. an global adoption of low-input sustainabl agriculture. In this sense, "low-input" may be a misnomer, and the term "sus tainability" may more fully reflect a ke objective of future agricultural policies

We also assume that "sustainability" refers to the U.S. and global farm secto in the aggregate and not necessarily t every farm and acre now in productio To the contrary, we would argue tha distorted incentives from present-da programs keep some land and geo graphic areas in crop land and othe relatively intensive uses when sociall optimal land and resource use plannin would suggest that such land should b taken out of production altogether o placed in less intensive uses. In margina production areas, sound long-term re source use probably implies significan economic and social adjustments for in dividuals, for whole communities, an for regions. Thus, the benefits resultin from adoption of practices and polici consistent with long-term sustainabili

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will not likely be without socio-economic cost. Who bears those costs and whether and how they should be compensated are aspects of low-input sustainable agriculture that need further research (U.S. House of Representatives, 1988).

Compatibility of LISA with alternative farm policies

Concern about sustainable agriculture comes in part from distortions in resource use driven by federal public policy for the farm sector. The most obvious distortions are those impelled by agricultural programs that provide strong incentives to expand production coupled with restraints on production in the form of acreage limits. In two ways, farm programs motivate farmers to use more fertilizers, pesticides, irrigation water, and other inputs: (1) higher prices raise the economic break even level of input use on a given acre of land, and (2) acreage restrictions mean farmers can increase production only by using more nonland inputs.

These generally accepted conclusions suggest that policies which reduce production by restricting land use are incompatible with the objectives of LISA. Policies in this category include traditional farm commodity programs as they have been operated since the 1940's and as they tend to be operated today. Even though these programs have been primarily voluntary since farmers voted out mandatory controls in the 1960's, their distinguishing features continue to be high incentive prices coupled with (often) large acreage reduction programs. Furthermore, for much of this period, several kinds of subsidies on credit, water, and occasionally other inputs have been available. All of these subsidies have served to reduce the cost of purchased inputs relative to land and to increase the profitability of production, hence the incentive to use more such inputs on a sometimes artificially limited land supply. These programs have generally encouraged specialization and intensive use of water, chemical fertilizers, and pesticides, and have discouraged crop rotations, crop-livestock enterprise mixes, and other practices considered consistent with LISA. This is not uniformly the case, of course, as we have seen growth in such conserving practices as no-till and low-till.

Given the distortions caused by present programs, it should be obvious that policies that depend on mandatory acreage cutbacks to support high domestic farm prices at low budget costs (such as the "Family Farm Act" proposed and widely debated in 1987) would be equally, if not more, inconsistent with the objectives of low-input sustainable agriculture. The higher the promised price supports, the greater would be the acreage cutbacks required, and the greater would be the incentives to beat the system by increasing the amount of water, chemicals, and other technology on the acres remaining.

Policies with the greatest natural compatibility with low-input farming are those that would price all inputs at their marginal social value without placing artificial constraints on the mix of inputs used in production. In other words, policies which would act to internalize the social costs and benefits of all production practices and resources into the farmer's decision process would be favored because all products of that process would be priced at their marginal social value. Socially accurate supply and demand signals would then drive farm sector decision making.

No programs seriously discussed in recent times meet all the criteria for natural compatibility with LISA. However, three types of policies have some of the required characteristics: (1) the market-oriented proposals made by the United States in the GATT negotiations, (2) mandatory supply control programs utilizing marketing quotas rather than acreage controls, and (3) a Pigouvian or penalty tax on producers to pay for environmental cleanup costs. None of these policies would necessarily internalize all the social costs and benefits of practices into the farmer's decision process. However, they would allow farmers to use a cost-effective mix of land and other resources to produce food and fiber, and all would likely result in less intensive land use. Under these policies, farmers would be motivated to reduce costs of production.

A mandatory supply control policy with fixed price supports and marketing quotas has its drawbacks. In addition to leaving the United States less competitive in world markets (unless exports were heavily subsidized), such a policy would lock in existing patterns of production among farms and regions, patterns not necessarily consistent with good use of soil and water.

A "polluter pays" tax would have similar drawbacks unless all exporters adopted similar criteria for environmental quality standards. An information problem does exist though when trying to determine the amount of pollutants for which each producer is to be taxed both in measurement and in terms of equity. Many European countries are currently adopting "polluter pays" legislation relating to agriculture. Perhaps these experiences both in policy formulation and program implementation will be instructive for U.S. deliberations.

The U.S. proposal in the GATT negotiations would gradually eliminate distortive subsidies and replace them with non-distortive assistance. Farmers would then produce the mix and level of commodities and employ the mix of resources most to their advantage. This would probably lead to less intensive use of land, reduced per acre application of water and chemicals, and return production to naturally productive regions and farms, leading to some human and resource adjustment costs. If the policy reform were multilateral - that is, all countries participating - U.S. export opportunities would probably increase (although not for all commodities) and more efficient use of global soil and water resources would occur, and with less environmental degradation.

Agricultural production and environmental quality tradeoffs

In effect, farm commodity policy regimes that attempt to manage production by controlling one input, land, impose two kinds of distortions on production practices and embody two kinds of subsidies to farmers. The first distortive subsidy is that which provides,

through target prices and other incentives, signals to farmers to apply additional nonland inputs to the artificially reduced number of acres on which production is allowed. The second distortion comes from the subsidy implicit in not requiring farmers to pay (internalize) the external costs of their practices. These costs or externalities result from agricultural residuals, including nitrates and other fertilizer nutrients, pesticides and byproducts, soil particulates, and livestock waste runoff that affect surface and ground water quality, wildlife habitat, and other environmental amenities.

Externalities in this context refer to the off-site costs borne by the public to correct environmental degradation that occurs as the result of agricultural activities. These off-site costs are sometimes referred to as the natural resource costs of production. They are associated with the consequences of private use of water, air, and soil resources by farm operations and are usually not borne by these operations. Rather, the private firms, in this case farming operations, can be characterized as using these nonpriced inputs in their production process without cost because the cost is really borne by society. Neoclassical economic theory suggests that these free nonpriced or environmental resources will be used by the firm until their marginal-value product is driven to zero. Thus, as a result, farmers attempting to maximize profit and their financial sustainability realize a different production cost function than does society when externalities are present.

Some portion of the LISA discussion has developed toward examining the value that the public places on environmental quality and to what extent and who will bear the externality or off-site costs associated with the production of agricultural commodities. We expect that demand for information to feed this examination will increase greatly. In the meantime, the public and policymakers will probably push for regulatory and administrative actions that will affect commodity production, restrict input use, change the availability and property use rights for natural resources, and provide different incentives for alternative production practices. Moreover, the recent and increasing focus on the relationships between environmental quality and human health will probably drive the debate over social and private costs of production, and social and private incentives to alter the level and mix of production inputs and commodities.

In a market economy, producers and consumers rely on the marketplace to send correct signals via prices and quantities to allocate scarce resources among competing demands. This theoretical system breaks down, however, when production or consumption externalities occur. When this happens, the marketplace does not always send correct price signals to indicate efficient or optimal resource use and allocation. For example, cropland runoff can affect the water quality of lakes and streams, and agricultural chemicals can leach into ground water. Consequently, true costs of producing food and fiber are not fully reflected in commodity prices. Thus, an inefficient allocation of resources can occur and public welfare may not be maximized.

These tradeoff relationships can be partly demonstrated through Figure 1, which begins in quadrant IV and then moves counterclockwise (Baum et al., 1989). Quadrant IV depicts the tradeoffs among commodity output or yields and input use. This is the traditional economic paradigm that expresses the positive relationship between input use and commodity production. For any given technology, production increases as input use increases. In quadrant III, the relationship between the amount of inputs applied and the amount of inputs not used by the commodity for growth is described as a linear function. This relationship is a technical agronomic relationship rather than economic and demonstrates the interdisciplinary linkage for these types of tradeoff analyses. Although this function could also be drawn as nonlinear, it expresses the concept that excess or unused inputs increase directly with the amount or intensity of total input supplied. At low levels of input use, the amount of excess input is nonexistent or at low levels.

The potential for environmental damage as a function of excess inputs is shown in quadrant II through the use of a pollutant or waste delivery functio Not all excess chemical or nutrient i puts are released into the environme to cause degradation. Some compoun are broken down through photosy thesis, are biologically unstable, or ca be used by other plants and organisn in the environment without ecologic disruption. For example, additional lan next to streams, ponds, and other wate ways as a result of the Conservation R serve Program (CRP) will act to remo many pesticides and nutrients from th environment before they are deposite in surface water sources. This is also technical, rather than an economic, r lationship based partly on biologica chemical, ecological, and soil science r lationships. This relationship also drawn to reflect a low or nonexiste pollutant delivery at low levels of exce input use to show the naturally occu ring ecological cleansing capacity of th environment. At a higher level of inp use, the potential environmental damag or degradation increases at a faster ra than does the level of excess inputs b cause the environment (soil and groun and surface water) becomes increasingl unable to break down pollutants into b nign elements, to rebuild needed nu trients, or to replace soil through organ decomposition. However, at very hig levels of excess input use, this curve b comes asymptotic because nearly all the additional excess input is reachin the environment.

The environmental quality (or dam age) curve in quadrant I is a derive function based on the technical and ec nomic relationships expressed in th prior three quadrants. As commodit production increases on a given plot land, using the technology illustrate the level of possible environmental de radation also increases. This function also drawn asymptotic to reflect the no linearity of the production function an delivery curve. Intuitively, the relatio ship suggests that at a certain level excess inputs and complete delivery ra tio, the quality of the environment wi deteriorate rapidly. At some point, dam age will reach a maximum and the e vironment destroyed.

For example, at input level X, we a at point A on the indicated productio

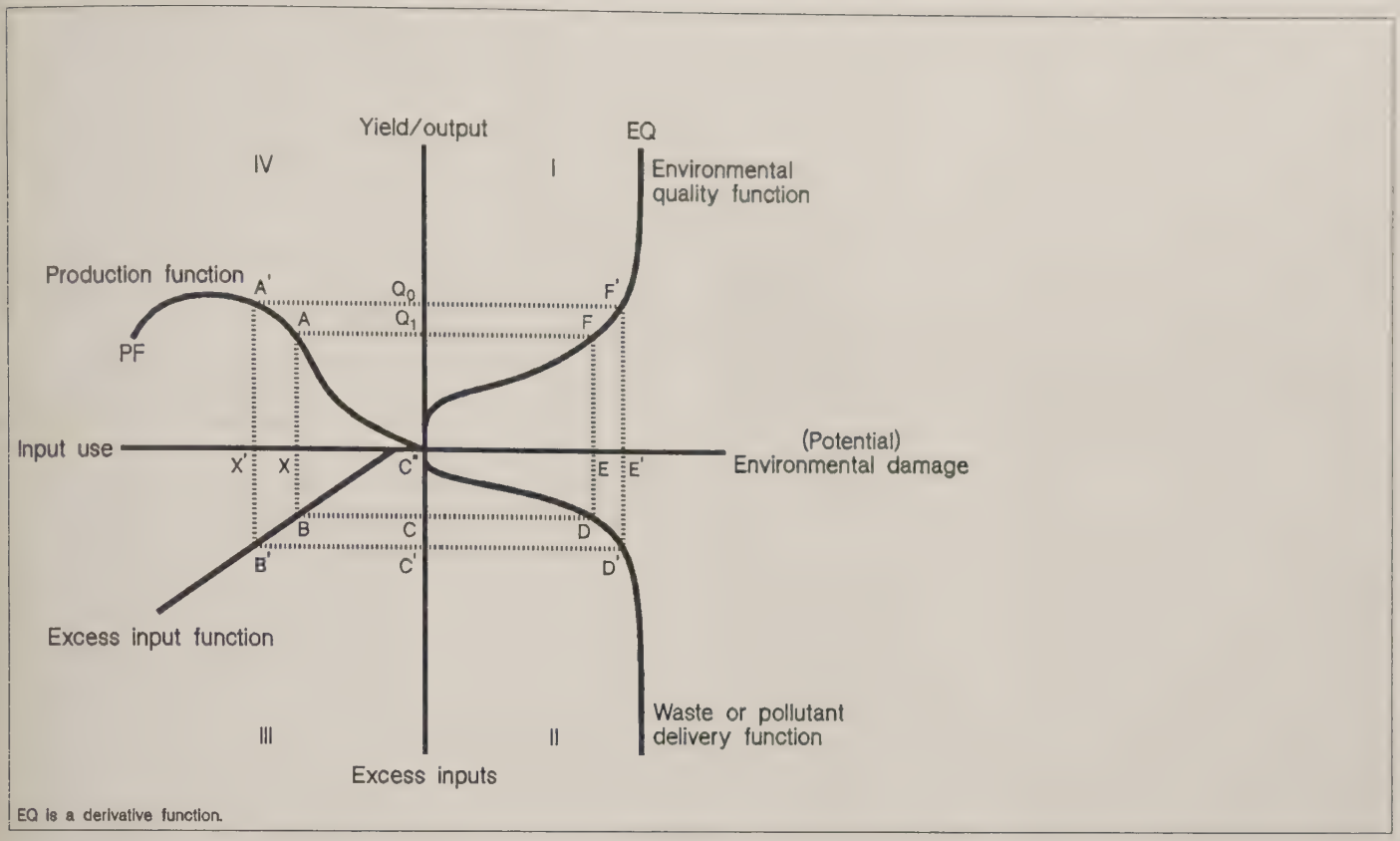

Figure 1. A conceptual diagram linking (potential) environmental damage, input use, and agricultural output levels.

function in quadrant IV and are able to produce quantity Q. At this production level, plants are not able to fully use applied inputs such as fertilizer. This results in an excess (or nonused) input level of B based on the hypothesized linear excess input function in quadrant III. At this level of excess input use, the delivery ratio level is point D, relating to potential environmental damage of level E. This potential environmental damage level of E results in point F on the environmental quality curve that relates environmental quality to the original production level A.

If a higher level of output, A′, results from, say, higher program subsidies or higher market prices, the following would occur. First, the level of input use would increase to X′ and the level of excess input use would increase to C′. Second, given the nonlinearity of the delivery ratio function, potential environmental damage would increase more than proportionately to E′, and society would move further out on the environmental quality curve, thereby trading increased output for decreased environmental quality. This scenario can be repeated for any number of other hypothetical situations to demonstrate the tradeoffs among commodity policy, input, resource, and management intensity, and environmental degradation.

These relationships, while useful for a simple illustrative demonstration, would need to be determined quantitatively for any actual analysis that involved choices among different output levels, export capability, and environmental quality. Nevertheless, the internalization of external resource or environmental costs associated with agricultural production would probably result in a lower level of commodity production and higher prices, assuming other important variables, such as technological change or current acreage reduction programs, were held constant.

Natural resource use and international competitiveness

The increased use of land and water as a result of trade expansion in the 1970's created growing concerns about use of our natural resources and possible environmental degradation. Some economists suggested that our soil was being exported along with U.S. commodity exports (Doering et al., 1983). Analysis of the National Resource Inventory data collected by USDA suggests that much of the 20 million acres of pasture, range, and idle land used for commodity production between 1975 and 1981 was highly susceptible to wind and water erosion. Approximately 1.1 million acres of wetlands were used as new acreage for crop production during this same period. Sutton (1988) suggests that these conversions very likely reduced fish and wildlife habitat, depleted the water recharge area necessary for natural flood

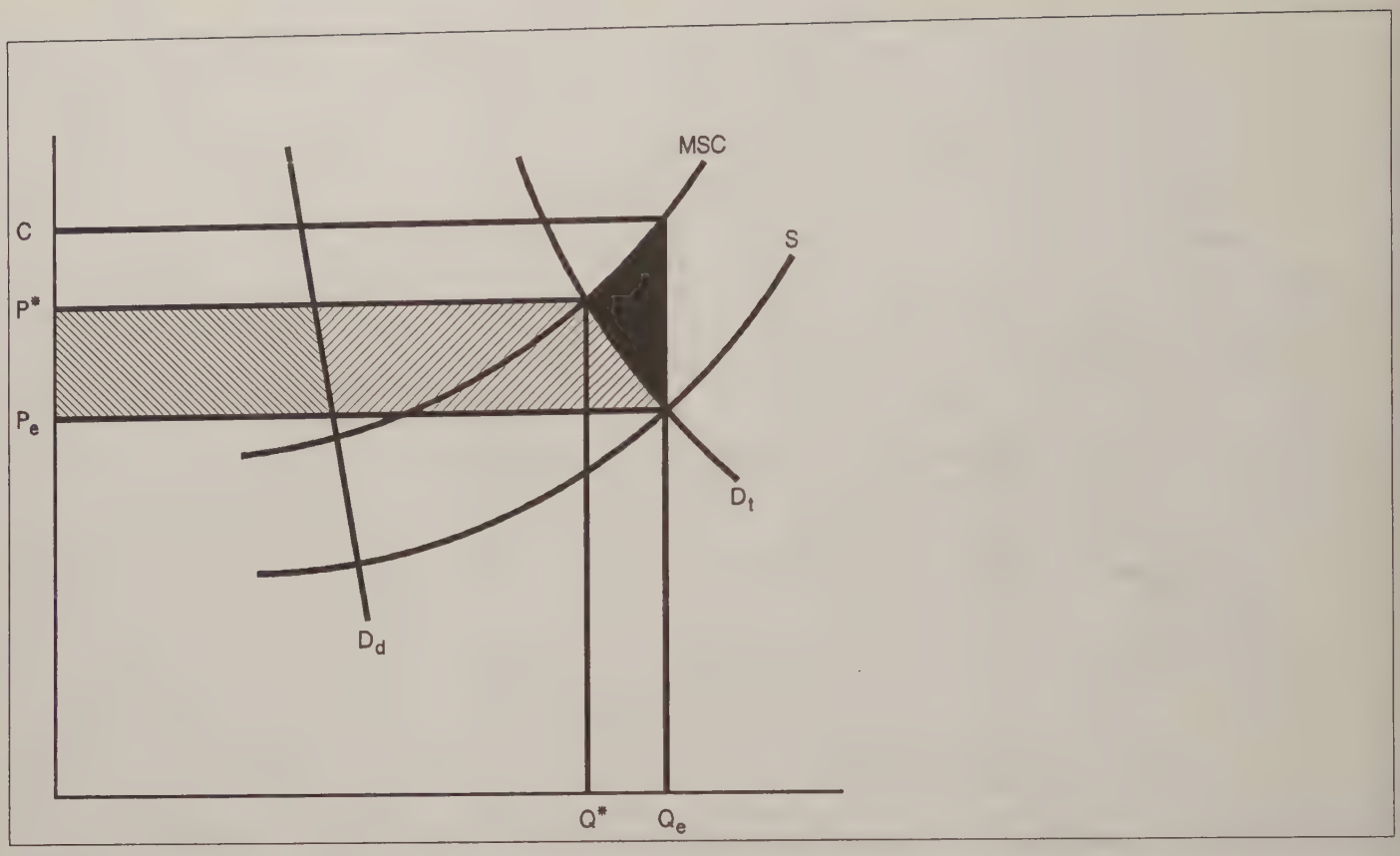

Figure 2. Commodity exports with external costs of production.

control and filtration of pollutants, and diminished (for some individuals) the potential for aesthetic enjoyment and recreation. Greater use of irrigation and increased application of agricultural chemicals led to greater concentration of salts, pesticides, and fertilizers in surface and ground water.

The social losses associated with such externalities have been examined by Gardner (1988) using elementary welfare economics. The supply and demand for an exported crop with a demand elasticity less than unity is shown in Figure 2. Total demand, Dt, is comprised of domestic demand, Dd, and export demand, which is the horizontal distance between Dd and Dt at any price. A market equilibrium occurs when Dt equals supply, S, at price Pe, and quantity Qe. Externality costs associated with agricultural production, such as soil erosion or water contamination with agrichemicals, are reflected by adding the marginal social costs or production, MSC, at each level of production. A case could be made that MSC would be increasing directly with production rather than constant as demonstrated here. Nevertheless, given positive costs associated with externalities, the socially correct level of output falls to Q^* and price increases to P^*, where marginal social costs now equal the market price. Thus, if output were increased from Q^* to Qe, the value of the added products produced would be the area below Dt and between Q^* and Qe. The added costs would be the area below MSC between Q^* and Qe. The net welfare loss would be the shaded triangle.

At the original equilibrium, the move from Q^* to Qe is beneficial to consumers because the market price falls and consumer surplus increases by the amount of the hatched area. However, the fine lined area or the surplus welfare gain accrues only to importers. Thus, the net loss to the United States is not just the shaded triangle, but also the fine lined area. Consequently, Gardner concluded that "exporting soil" really does involve losses over and above those from losse of soil for the sake of domestic con sumption.

LISA and competitiveness: Alternative policy scenarios

How would the adoption of low-inpu sustainable agricultural practices affe the competitive position of U.S. agr culture in world markets? Unfortu nately, an empirical analysis of th question is not currently available. Th site-specific nature of LISA applicatio and the highly variable results of thos applications suggest that LISA woul leave some individual farmers mo competitive and some less so. The n result is problematic.

We do feel that the overall impact the widespread adoption of LISA c U.S. competitiveness in world marke will be affected by: (1) the overall U. and global farm and trade policy milie (e.g., the extent of market-distortin

subsidies), and (2) whether the adoption of low-input, environmentally desirable practices is achieved voluntarily or by regulations (e.g., the internalization of external environmental costs).

Current trade policy and U.S. agriculture

In the present trade environment and with present U.S. policies (1985 Food Security Act), it is not clear that widespread adoption of LISA technology is likely, especially for the major export commodities (grains, oilseeds, and cotton). With the exception of oilseeds, these same commodities are among the major beneficiaries of the highly distortive subsidies and acreage reduction programs. A review of recent studies (Daberkow, et al., 1988; Domanico, et al., 1986; Helmers, et al., 1986; Dabbert and Madden, 1986; and Goldstein and Young, 1987) involving a variety of commodities and locations reveals a wide range of results on profitability of and, hence, incentives to adopt, low-input, environmentally sustainable agriculture. The current high level of government payments and heavy dependence on acreage-reduction programs, however, suggest continuing strong incentives for conventional production practices to continue. In addition, U.S. farmers are further discouraged from giving up these distortive practices and subsidies by their awareness that most competing exporters also subsidize their farmers (Economic Research Service, 1988).

Internalization of environmental externalities and U.S. agriculture

It would appear that, under U.S. commodity policy regimes similar to those under the 1985 Food Security Act, internalization of the social and environmental costs of practices encouraged by those policies might have to be imposed on farmers through regulatory means rather than incentives. The imposition of an implicit or explicit cost on environmentally degrading agricultural practices raises costs and thus shifts the domestic supply curve to the left (that is, for a given price, farmers are now willing to supply less than before). This reduces supplies on the global market and increases demand for exports from other exporters. The net result, other things being equal, is a modestly higher world price, a smaller export share for the United States, and larger export shares for other exporters.

Although it is clear that a high percentage of U.S. commodity production is competitive in international markets, there are a number of other areas in other countries that are also low-cost producers (Vollrath, 1987). The supply of commodities from these areas added together with production in excess of domestic demand can be summed into a total world supply available for export at various prices, as shown in Figure 3. The total world supply curve, S_T, is comprised of the export supply from other countries, S_O, and the U.S., S_{US}. Since the world supply curve is the horizontal sum of S_O and S_{US}, it is the kinked curve P_0S_T. Below price P_0, world exports are nonexistent. But at a price above P_0, exports increase as prices increase beginning with the lowest cost supplier. For wheat, the lowest cost competitive suppliers are first Argentina, and then Australia, Canada, and France. At the prices below P_1, these suppliers have large market shares and the U.S. would not enjoy a market share. As world demand increases and the price rises above P_1, the U.S. market share increases. At P_2, the U.S. and the rest of the world share the export market equally, and as demand increases and price rises to P_3 and beyond, the U.S. captures a dominant market share. Given various levels of market demand and limited, but lower cost supplies by other countries, this situation can provide an appearance of the U.S. acting as a residual supplier. However, in reality, this demonstrates the dependence of the U.S. on the total level of world demand and the relative importance of access and opportunity to sell commodities in export markets to improve market share and dispose of excess supply over domestic demand (Vocke, 1988).

The relative importance and effect of the inclusion of the social or resource costs of production on U.S. competitiveness can also be demonstrated with Figure 3. If social costs of production are now added unilaterally to the private costs of production, the supply curve for U.S. exports shifts upward to S_{US}. As discussed earlier, it is likely that this curve will also rotate to the left (or become steeper) if these additional costs increase directly with the level of production. If so, the new world supply source S_T will also shift upward and rotate to the left. Now, the price must rise above P_1 for the U.S. to find an export market for the commodity in question. Thus, analytically, at any price above P_1 plus the additional social production costs, the U.S. market share will decline. In order for the U.S. to again regain an equal market share with other exporting countries, price would have to rise to P_3. The amount of decline will, of course, depend on the relative elasticity of U.S. export supply reflecting the social costs of possible environmental degradation, including groundwater contamination, and the location of commodity import demand.

The results depicted in Figure 3 are general and would apply for any set of production practices that do not represent a socially optimum use of resources (that is, where all private and social costs are not fully reflected in the farmers' cost of production and in the prices of commodities produced). Obviously, the greater the divergence of present practices from those that are socially optimum, the greater would be the loss to U.S. competitive position and market share resulting from farmers having to internalize social costs of production.

Some implications of trade policy

The distortions caused by restricting land use under traditional farm programs would be sharply reduced under proposals recently put forth under the General Agreement on Tariffs and Trade (GATT) by U.S. negotiators. The proposals call for all nations to phase out all market distorting subsidies over a 10-year period (roughly, by the year 2000), but nonmarket distorting assistance to farmers would still be permitted (Economic Research Service, 1988).

Trade policy reforms that might result

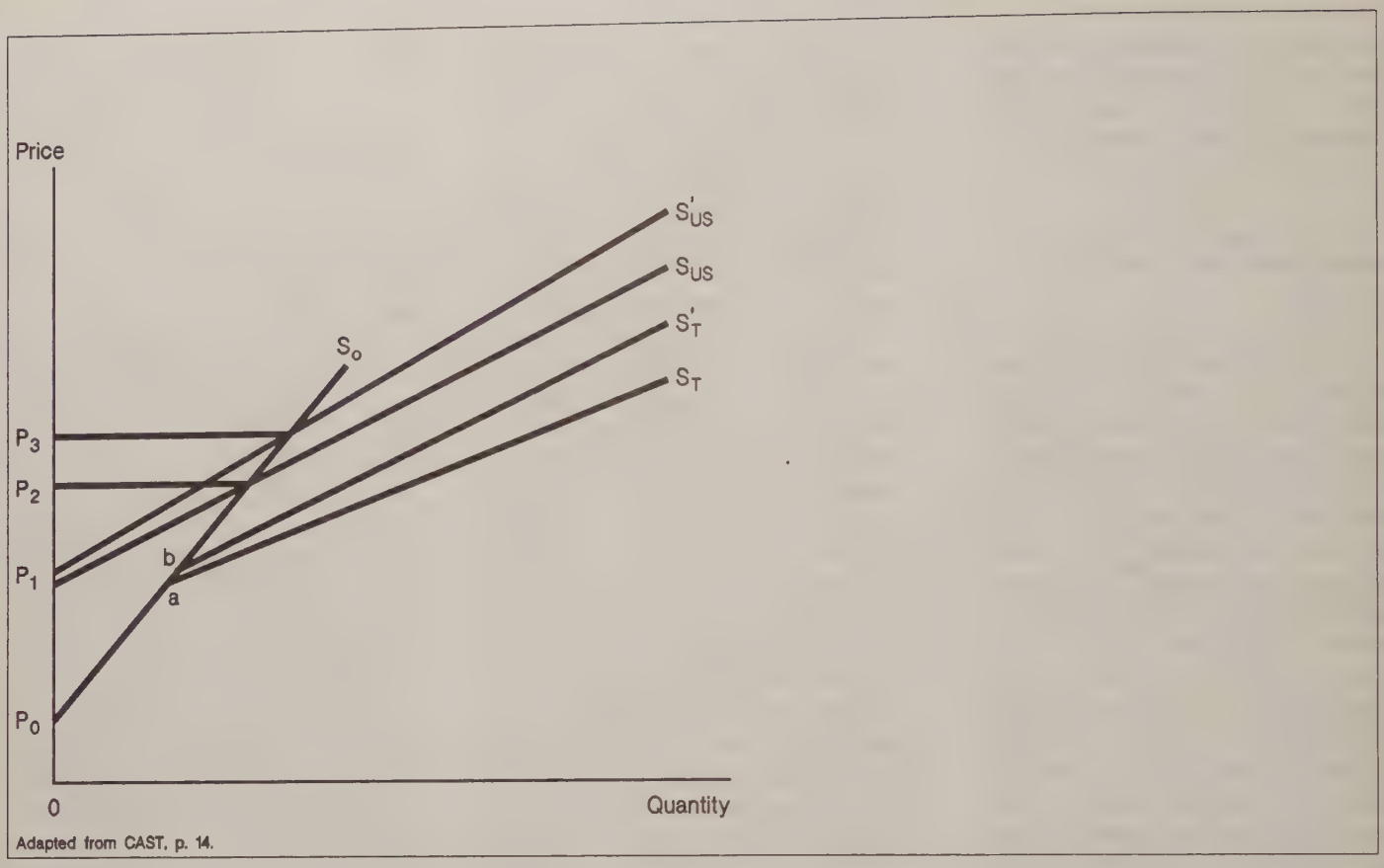

Figure 3. Relative shifts in the U.S. exports supply curve, other exporters, and the total export supply curve.

from the GATT negotiations, particularly full trade liberalization, would undoubtedly change the mix and levels of commodity flows between the United States and other nations. If so, they would also affect the intensity of use and value of our land and water resources and input use in major producing regions (Sutton, 1989).

The full implications of trade liberalization and the elimination of market distorting subsidies are not well known. However, the studies done thus far are consistent in terms of the general directions of outcomes (Meilke, 1987; Parikh et al., 1986; World Bank, 1986). With the elimination of incentives to overproduce in the major developed nations, production in those nations would decline and world prices for commodities would rise. Cropland acreage would probably decline in Japan and in the European community and rise through land extensification but with less intensive input use in the United States, Canada, and Australia. These preliminary results suggest that U.S. exports of wheat, coarse grains, and oilseeds would range from little change to significant increases. U.S. exports of beef could rise sharply (an interesting result given the compatibility of livestock systems with LISA practices). But, with removal of all trade barriers, we could see some increase in imports of sugar and dairy products.

The net results across all commodities suggest that, with modest overall increases in export volume and with higher world prices, market-generated income to the U.S. farm sector (exclusive of government payments) would be substantially above current levels, and cost the government substantially less than under present programs. Thus, the competitive advantage the United States now has in producing a number of major export commodities (grains and oilseeds among them), as well as commodities that could become important sources of export earnings (beef and possibly other meats), suggests that multilateral trade liberalization and policy reform could lead to more socially optimum production practices.

Environmental externalities occurring as a result of agricultural production would probably be significantly reduced but not eliminated in these circumstances. However, we do not yet have reliable total estimates of these additional social costs, or for specific crops and regions. Consequently, if market distortions of present commodity programs were removed, here and abroad, the extent to which all remaining external social costs were internalized would determine how our global export competitiveness would be affected. Obviously, if the U.S. unilaterally required our farmers to internalize these costs, our competitive advantage would diminish.

Nationally, at the margin, the effects would probably be modest. Neverthe-

less, we would have a vested interest in encouraging other nations to adopt practices consistent with a sustainable environment and thereby help assure a more level competitive playing field.

Some progress is being made. The 1985 Food Security Act has provisions to discourage sodbusting and swampbusting and requires farmers to have plans in place by 1990 to meet soil erosion requirements or lose access to farm program benefits. Water quality initiatives at the federal and state levels, and a host of other recent federal and state initiatives, are aimed at reducing socially undesirable side effects of agricultural practices. Likewise, in Europe, environmental concerns have led to pressures to modify agricultural practices to reduce perceived hazards to the environment and to human health (Young, 1988).

Recent data on the costs of producing wheat provide an interesting case study of how producers of that commodity might fare under liberalized trade. Glaze and Ali (1988) have recently estimated a production cost distribution curve for U.S. wheat production in 1986 using the USDA Farm Costs and Returns Survey data (Figure 4). This procedure eliminates the bias present in previous cost of production studies using state average budgets and then aggregating to regional and national estimates. In 1986, prices received by farmers were just a little above the loan rate, $2.40, and the target price was $4.38. For 1988, the loan price had dropped to $2.21, the expected market price had risen to $3.55-$3.85, and the target price had fallen to $4.23 (USDA, 1988). These target prices cover cash expenses for almost 95-98 percent of production and total economic costs for about 80-85 percent of production. Market prices of $2.40 and $3.70 cover cash expenses for about 80 and 95 percent of production, respectively. However, these same market prices cover total economic costs for 25 and 75 percent of production, respectively.

Glaze and Ali (1988) also note in their analysis that the lowest quartile, mid-range, and upper quartile of farms reported average fertilizer expenses of 20, 41, and 95 cents per bushel, respectively, and 4, 14, and 44 cents for chemicals per bushel, respectively. Yields fell from 38.4 to 34.3 to 16.1 bushels moving from the low-cost to the high-cost farms. Even given different resource endowments, soil fertility, and the possibility of crop failure, higher cost producers were apparently using much higher levels of fertilizers and pesticides to produce 8 percent of U.S. wheat, and are probable sources of environmentally degrading agricultural residuals. These farms would also be the most likely affected by changes in world market prices in terms of incentives to leave or continue production. Further analysis could disaggregate these statistics to provide refinement of possible effects of LISA adoption and trade liberalization.

Trade liberalization would free farmers to use the most cost-effective mix of land and other ingredients to produce wheat. That would probably mean use

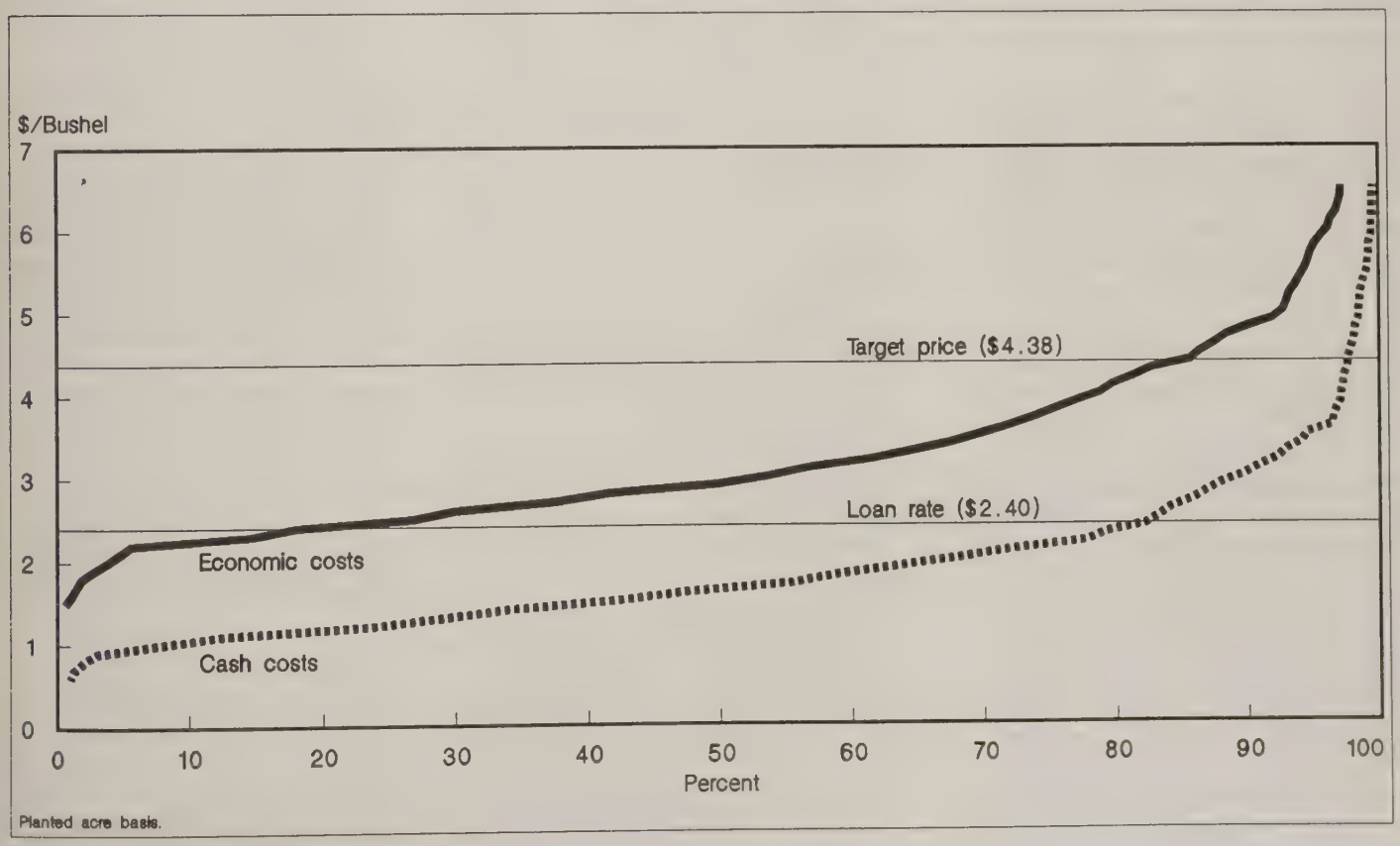

Figure 4. Cumulative distribution of U.S. wheat production by total cash and economic costs of production per bushel, 1986.

of more land relative to other inputs (that is, less intensive land use) and lower overall unit costs of production. The cost curves in Figure 4 would then shift to the right. Market prices would be higher, but probably well below current target prices. This would strengthen the relative competitive position of low-cost producers.

If commodity producers were further required to internalize costs of undesirable environmental effects, and if the data correctly suggest that responsibility for environmental degradation is greater among high-cost producers, the resulting cost curve would be higher on average but would probably tilt further in favor of current low-cost producers. Depending on who the farmers are at the low-cost end of the curve and where they are located, a combination of trade liberalization and LISA practices could have potentially significant structural and regional adjustment implications. The potential importance of those implications suggests the need for more research and information than we now have.

Summary and conclusions

We don't know enough to provide a definitive answer to the question, "How would the imposition or achievement of low-input, sustainable agricultural practices affect the competitive position of U.S. agriculture in global markets?" But we do know enough to say that resource use distortions and environmental/social costs of farm practices are exacerbated by programs that attempt to constrain production by constraining land use. LISA objectives would be furthered by adoption of proposals for reduction of distortive farm commodity payments. Recent studies also suggest that multilateral adoption of such proposals would probably improve the overall competitive position of U.S. agriculture in world markets, increase market-generated revenues, and reduce the cost of any nondistortive assistance needed to maintain farm income. Further internalization of any remaining social costs of production associated with environmental degradation would add to farm production costs, but the extent to which the U.S. competitive position would be hurt would depend on their relative addition to total costs of production *and* on the extent to which producers in other competing countries would need to internalize similar environmental social costs. Keys to reducing these latter environmental costs, hence to maintaining our competitiveness while not incurring undesirable social costs, include technology and more efficient input use management practices. Thus, the objectives of LISA are likely best served by support of policy reforms, worldwide, which would reduce incentives to distort the level and mix of resource use and by support of research and education to further the development and adoption of technologies and more efficient input management practices consistent with a safe and sustainable agriculture.

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Sustainable agriculture: Policy options and prospects

Charles M. Benbrook

Abstract. *Complex policy issues and tradeoffs will arise in crafting the 1990 or 1991 Farm Bill. Efforts to advance progress toward sustainable agriculture production systems could arise in the farm bill's commodity, conservation, and research titles. Key definitional issues are highlighted here, as well as water quality issues and the impact of ongoing GATT negotiations in the context of increasing global demands on American agriculture.*

Key words: sustainable agriculture, agricultural policy, water quality, cropping systems

Introduction

Sustainable agriculture has passed into a new phase of its conceptual and political development. As a new farm bill takes shape in Washington, public discussion is focusing on whether and how public policy should encourage more widespread adoption of alternative production practices and systems that place more emphasis on exploiting positive biological interactions, on resource stewardship, and on the efficient on-farm management of agrichemicals and animal manure. In many parts of the country, such systems are viewed as a cost-effective option to reduce off-farm environmental effects, while also improving profitability. At a minimum, the next farm bill is likely to include reforms intended to reduce some of the more obvious policy-related penalties and constraints that discourage adoption of alternative practices, particularly crop rotations. The farm bill will also, in all likelihood, include several research and extension initiatives.

Attempts to conceptually describe a more sustainable agriculture are leading farmers, researchers, and agricultural leaders to ask key questions about the economic and environmental outcomes of farming systems and practices. Innovators--from the field to the laboratory and in the halls of government--have found ways to take advantage of linkages between the economic and environmental performance of farming systems. Concurrently, interest in alternative agriculture is growing, particularly in areas beset with serious problems involved in conventional production systems. Problems compelling farmers to seek alternatives include economic pressures brought on by falling government target prices and by market forces, resistance to pesticides, post-secondary pest resurgence, the buildup of soil-borne insects and root diseases, soil compaction, ground water contamination, and difficulties in meeting the goals of conservation compliance erosion control.

Release of the Alternative Agriculture report

On September 7, 1989, the NRC report *Alternative Agriculture* was released in Washington. Newspapers across the country gave the report prominent coverage, often running two or three stories on it within a week of its release.

The major attention paid to the report arose, I believe, from the public's growing interest in agricultural, environmental, and food safety issues and from its basic message--that alternative agriculture systems offer great potential for simultaneously improving the economic and environmental performance of American agriculture. The report points to ways in which the nation can utilize emerging science and new management skills to strive toward a productive and profitable agricultural economy while at the same time keeping long-standing commitments to resource stewardship, a clean environment, and safe food. Most people consider this good news. Still, some people--particularly in certain agricultural industry trade associations--doubt that farmers can really make progress toward both goals. Moreover, confusion persists over the definition of alternative agriculture.

What is alternative agriculture?

Because farming systems across the country are by necessity so different, the committee that wrote our report decided to define "alternative agriculture" in very broad and general terms. The committee points out that there is no single intrinsically correct definition of alternative, sustainable, regenerative, or low-input sustainable agriculture (LISA).

One important conceptual issue is whether alternative agriculture is conceived of as a process or defined as some distinct set of practices. The answer to this question is of considerable practical significance if policymakers choose to

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The views expressed herein are the author's own.

incorporate new incentives for the adoption of alternative agriculture into legislative initiatives. The ongoing debate about the definition of alternative/sustainable/LISA agricultural systems will take on a different tenor and tempo if Congress attempts to incorporate these concepts into the rules governing eligibility and payment levels in current agricultural commodity and conservation programs.

Our report defines "alternative agriculture" as a system of food or fiber production "that systematically pursues the following goals: ...nutrient cycling,...IPM, greater productive use of biological and genetic resources,...better match in cropping patterns and the physical limitations of available resources, profitable and efficient production..." In the report's definition, the distinguishing characteristics of "alternative agriculture" are the approach or strategy a farmer uses in reaching management decisions and a heightened commitment to natural resource stewardship and environmental protection. In short, the definition stresses the general goals and concepts in the farm management decision process, not a discrete specific outcome.

Producers are continuously modifying farming and animal management systems whenever an opportunity appears to arise for increasing productivity or profits. Management decisions tend to be made not just because of one goal or concern, but in the context of the overall performance of the farm, taking into account available resources, prices of inputs and outputs, technology, and any pertinent programs and policies. It is also important to acknowledge that the search for alternative production practices can usually be traced to an emerging problem with the performance of conventional practices, a change in government policy, or newly available technology.

In the early 1980s, economic problems were clearly the incentive behind farmers' search for cost-cutting management strategies. In the 1990s, however, pressure to lessen agriculture's adverse impacts on the environment may become equally pervasive and could also help continue reducing costs of production. Indeed, the many underlying linkages between the economic and environmental performance of farming systems is a recurring theme highlighted throughout *Alternative Agriculture* (NRC, 1989).

Regrettably, agricultural researchers, policymakers, and most farmers lack concepts and methodologies that are useful in sorting out many important on-farm economic and environmental linkages. For example, farmers lack a practical method to monitor soil compaction, and hence may fail to recognize the need to alter tillage practices and crop rotations. Since compaction reduces water infiltration and increases runoff, it can both reduce yields and economic performance and exacerbate surface water runoff and erosion losses. Other examples include the lack of detailed knowledge of on-farm nitrogen cycles, soil-borne pathogen levels, the number of pesticide-resistant insects in a given population, and soil salinity levels through the soil profile.

The lack of knowledge about these linkages makes it difficult analytically and administratively to apply our definition of alternative agriculture to many contemporary farming systems, particularly at any one point in time. Moreover, the nation lacks a well-developed empirical basis, grounded in solid science, to specify a discrete set of changes in farming practices and methods that will turn a "conventional" system into an "alternative" one.

Definitional issues will need to be clearly and carefully settled as an important, early part of the process of designing and debating potential policy reforms. A necessary first step is to understand the differences between a farming practice, a farming method, and a farming system. Once these terms are mastered, discussion can then focus on how to determine what a "conventional" practice, method, or system is and how an "alternative" or "sustainable" practice, method, or system might or should differ from a conventional one. The following discussion is drawn from definitions in the glossary of *Alternative Agriculture* (NRC, 1989).

A *farming practice* is "A way of carrying out a discrete farming task such as a tillage operation, particular pesticide application technology, or singl conservation practice." Most importan farming operations--preparing seedbed, controlling weeds and erosion or maintaining soil fertility--require combination of practices, or a method Most farming operations can be carrie out by different methods, each of whic is a unique combination of differen practices.

A *farming method* is "A systemati way to accomplish a specific farming ob jective by integrating a number of prac tices." A discrete method is needed fo each essential farming task, includin preparing a seedbed and planting, man aging irrigation, collecting and disposin of manure, controlling pests, and pre venting animal diseases.

A *farming system* is "The overall ap proach used in crop or livestock pro duction, often derived from a farmer goals, values, knowledge, available tech nologies, and economic opportunities. A farming system influences the choic of methods and practices used to pro duce a crop or to care for animals. A farming system is a combination o methods. A farming method intended t accomplish a discrete task (maintainin soil fertility, for example) is itself a com bination of discrete practices.

As the policy debate unfolds abou how to encourage progress toward sus tainable agriculture, attention will focu on questions such as:

- Where and why is conventional ag riculture unsustainable?
- What are appropriate performanc indicators to use in evaluating alterna tive production practices and systems What time frame should be applied?
- How can the economic con sequences of alternative systems--fo farmers, rural communities, and the na tion--be evaluated rigorously and com pared honestly and fairly with th consequences of conventional systems i light of current programs and policies

Two critical issues

Two issues are likely to become muc more prominent as the policy debate un folds. One relates to the growing pres sure on global agricultural resources t meet world food needs; the second t

reassessing how policy should accommodate increasing crop production levels without again setting the stage for resource base and environmental degradation.

World markets are tightening, prices are rising, and pressure is growing on U.S. agriculture to expand production. This pressure will build markedly if any unexpected factor should reduce 1990 yields in any major production region or if demand grows faster than anticipated, perhaps as a result of political upheaval in eastern Europe or efforts to satisfy long-standing consumer needs in the Soviet Union. Accordingly, advocates of sustainable agriculture will face an ongoing challenge in convincing skeptics that the only realistic way to reliably and markedly increase yields and production levels, without incurring markedly higher production costs and causing further environmental degradation, is through development of intensive biologically based production systems.

Such systems hold the key in meeting growing demand for U.S. farm commodities--not more chemical- and energy-intensive conventional systems. More diversified, biologically based systems will, over time, make it possible for farmers to relax stubborn resource-related constraints on higher crop yields, particularly in the major producing regions, where compaction and/or a loss of tilth is reducing the capacity of soils to quickly absorb and hold rainfall. Biological constraints to higher yields also must be overcome in areas where pests and root diseases remain difficult or are costly to control through reliance on currently available pesticides.

Crop yield barriers are appearing rather ominously on the horizon in many conventional production systems, both here and abroad. Indeed, a growing body of evidence (Ruttan, 1989) suggests that it will be difficult to even sustain current yield levels in some areas without steady increases in per unit costs, particularly if and as energy prices rise. On a more hopeful note, scientists perceive opportunities to raise realistically attainable yield goals by improving the quality of the soil itself as an environment supportive of root development and plant growth (see the statement of priorities in the Ruttan Dialogue report). Key steps in increasing soil productivity will entail improving the soil's capacity to take in and hold water, which is often the principal limiting resource in plant growth, and reducing the levels of soil insects and pathogens that can retard root development and plant health.

Many options can be pursued in an effort to increase soil productivity: improving soil tilth and organic matter content, reducing compaction, conservation tillage systems, rotations, and the use of rotations and cover crops in the fixation and biological cycling of plant-available nitrogen. Indeed, *Alternative Agriculture* (NCR, 1989) highlights the role of more effective use of soil and water resources, more extensive use of land and the growing season, and lessened loss of nutrients and crops to erosion and pests as the foundation of sustainable production systems that match--or exceed--the economic and productive performance of well-managed conventional systems.

The second emergent issue that warrants reassessment of policy options and priorities arises from what may become a dramatic shift in economic and political forces shaping farm policy. The 1980s were characterized by a major increase in the role of government in supporting farm income and asset values by affecting the outcome of farm sector land use, production, and investment decisions. It was an era of rapidly rising federal expenditures, which provided USDA agencies with opportunities to address a broader array of societal goals through existing programs and policies. Examples include the erosion control compliance provisions incorporated into commodity program rules and the Conservation Reserve Program (CRP).

The 1990s, on the other hand, are likely to witness deep cuts in commodity program expenditures, particularly relative to the 1986-1987 period. Also, the commitment of the United States to bring the ongoing General Agreement on Tariffs and Trade (GATT) round to a successful conclusion by the end of 1990 will undoubtedly influence the farm bill process (NRC, 1990).

The Administration has promised to resist farm bill proposals that would tend to complicate or undermine the negotiating position of the United States within the ongoing GATT round. Such proposals would include outright export subsidies or commodity program reforms that distort production patterns by artificially increasing prices received by farmers. Such policies are targeted in the most recent U.S. GATT proposal for phaseout over 10 years, since these are the policies that distort world trade most seriously. The recent U.S. proposal envisions progress toward policies that provide an equal measure of farm income protection but without trade-distorting impacts.

To strengthen the U.S. position in the GATT negotiations, the Administration is likely to recommend reforms in U.S. farm policy that provide farmers more flexibility in the manner in which acreage bases are used, coupled with more concrete resource stewardship provisions and requirements. A policy proposal that shifts a portion of current government program payments from an exclusive income support function to payments which help share the cost of resource stewardship investments would both advance our position in the ongoing GATT round and help address pressing national environmental needs. Achieving this policy objective in an era of strong demand, rising prices, and lessened incentive for farmers to participate in traditional commodity programs will force all participants in the farm policy debate to reconsider seemingly sacrosanct features of current policy, such as economic use of set-aside and CRP land, policies governing established yields and crop acreage bases, regulatory policies governing non-point sources of pollution, and payment limitation policies.

Creative new policies and programs are likely to emerge in the 1990s as the nation strives to balance progress toward improved farm profitability, economic responsiveness, and resource stewardship. Perhaps the most complex challenge will be accommodating the need for U.S. farmers to expand production and take advantage of market opportunities without unleashing a repeat of the government-financed environmental

and social problems of the 1980s that followed the "get big or get out" philosophy and the "fencerow to fencerow" policies of the 1970s.

Proposals taking shape on Capitol Hill represent a range of intriguing ideas on how to move U.S. farm policy in a direction consistent with resource stewardship needs and the nation's GATT position. The basic elements of such proposals include:

- Freezing crop-specific target prices at the 1990 level.
- Adopting a market-driven approach in realigning target and support prices across crops to eliminate the current disincentive for the planting of certain crops, in particular oats and soybeans.
- Providing farmers more flexibility in the manner in which crop acreage bases can be utilized without sacrificing current or future program benefits.
- Decoupling payments from crop-specific planting decisions and instead basing payments on pursuing more diverse cropping rotations coupled with compliance with plans developed to pursue resource and environmental stewardship goals.
- Relaxation of the so-called cross-compliance provisions which now prohibit many farmers from planting fall small grain cover crops and/or penalize farmers who adopt more diverse rotations.
- Under specified circumstances and mindful of economic implications, allowance of haying and grazing on set-aside and CRP land.
- More systematic incorporation of water quality protection goals into the basic provisions within current commodity and conservation programs.

This last goal--integrating water quality goals into the policy mainstream--promises to be a major focus in the 1990 Farm Bill debate.

Water quality: The policy challenges

Water quality is the most widespread environmental challenge confronting American agriculture (NRC, 1989). In some areas, farm leaders and agribusinesses fear the possible costs of policies imposed on agriculture in the name of water quality. Farmers worry that increasingly comprehensive environmental and resource stewardship policies could undermine their competitiveness or require an increase in government financial support in an era of shrinking fiscal resources. These fears may prove well founded for certain crops and types of farms in some parts of the country including:

- Intensively farmed fruit and vegetable production regions in Arizona, California, Florida, New Mexico, and Texas, particularly those above shallow aquifers also serving as a source of drinking water or in areas where salinity, selenium, or soil-borne insects or pathogens pose recurrent threats to plant productivity.
- Parts of the Corn Belt with relatively shallow and permeable soils or other geographic features conducive to downward movement of agrichemicals.
- Irrigated crop land with sandy soils in the sandhills of Nebraska, central Wisconsin, and other states.
- Regions with heavy concentrations of livestock relative to cultivated crop land including the fertile valleys of the northeast, areas with large feedlots in the Central Plains and west, and the poultry-producing areas of the Southern Piedmont.

The principal water quality challenge in the 1990s is reducing both the volume and portion of fertilizers and pesticides that do their job inefficiently because they get washed off plants, degrade microbially, or move too swiftly downward through the soil below the plant root zone where they are needed and can be utilized.

Chemical inputs that wash away are typically guilty of simultaneously causing several problems. They tend to increase farm production costs and result in poor cropping system performance. The crops often require additional agrichemical treatments, increasing economic and environmental problems. (In some cases, however, solubility of pesticides is viewed as a beneficial property for a pesticide. Solubility can reduce toxicity to mammals and birds, hasten degradation, and help assure more even penetration of the root zone.)

In advancing efforts to make agriculture more sustainable and to protect water quality, just lowering input level is rarely the answer. More complex changes will typically be required in crop rotations, tillage and planting methods, fertility maintenance, and pest control strategies. Some inputs will become less important; others will be relied upon more heavily.

Economic incentives, land use rules, technology and education priorities, and regulation are all important elements of policy currently receiving attention in the Congress. Each could impact agriculture's two major contributions to ground water contamination: nitrate from fertilizers, manures, and natural sources; and pesticides, principally those incorporated into the soil and/or used widely at relatively high rates (e.g., atrazine and alachlor).

Indeed, one of the *Alternative Agriculture* (NRC, 1989) report's most important findings highlights the effects of government policy:

"Many federal policies discourage adoption of alternative practices and systems by economically penalizing those who adopt rotations, apply certain soil conservation systems, or attempt to reduce pesticide applications. Federal programs often tolerate and sometimes encourage unrealistically high yield goals, inefficient fertilizer and pesticide use, and unsustainable use of land and water. Many farmers in these programs manage their farms to maximize present and future program benefits, sometimes at the expense of environmental quality."

The report notes that about 70 percent of the nation's cultivated crop land has been enrolled in commodity price support programs in recent years and that "program rules have enormous influence on agriculture." These programs have resulted in over $170 billion in payments to farmers in the 1980s and are likely to remain important factors in on-farm management decisions for years to come despite recent improvements in market prices and declining program expenditure levels.

The report also states that over time these programs have, in some areas for certain crops, had unintended adverse

consequences. Until important reforms in the 1985 Farm Bill, the commodity programs generally encouraged and often handsomely rewarded the:

- Planting of highly erodible crop lands ill suited to cultivation, the draining of wetlands for crop production, and the establishment of irrigation systems in regions with vulnerable ground water resources.
- Excessive application rates for certain plant nutrients--particularly nitrogen--in an attempt to boost crop yields and hence future program payments.
- Crop specialization, rather than rotations, and separation of crops from livestock within a region, trends that generally have resulted in increased dependence on certain pesticides and biological problems in production systems (pesticide resistance, soil compaction, manure management problems).

The report repeatedly stresses a key point that offers reason for hope that remedial actions addressing agricultural sources of nonpoint pollution can be largely self financing: the economic and environmental performance of farming systems are often closely interrelated. Farming systems that result in high per unit production costs often do so because of a mismatch in cropping patterns, natural resource conditions, and technology. High-cost systems tend to make poor use of purchased inputs and contribute disproportionately to pollution. Moreover, pesticide and fertilizer inputs typically account for at least 40 percent--and often 60 percent or more--of variable cash production expenses. It is for this reason that cost-conscious farmers in the early 1980s focused on innovative alternative practices to cut back on fertilizer and chemical expenditures, including split applications of nitrogen, banding of herbicides, use of rotary hoes and ridge tillage, crop rotations, IPM, and other alternative practices.

Nitrates: A critical water quality issue

Nitrate contamination of surface water and ground water is the most widespread water quality problem caused by agricultural activities. The problem arises from an excess supply of nitrogen in the root zone relative to the needs of growing crop. The loss of nitrogen to the hydrological cycle is exacerbated when excessive levels of nitrogen are present in the fall or during early spring when there is a relatively large volume of water moving across the soil surface or downward through the soil profile.

Evidence is mounting that nitrate problems are most serious in regions of the country where intensive livestock production enterprises result in the need for land disposal of large volumes of manure. Problems are also encountered in areas where livestock slaughter plants, food processing plants, or other industrial activity results in the need for on-land disposal of large volumes of organic materials.

Because of the need to produce animal forages in such areas, legumes are often included in crop rotations, adding additional units of naturally fixed nitrogen into cropping systems. For example, Wisconsin, a major livestock state, is the nation's leading producer of alfalfa relative to other cultivated row crops. Many farmers throughout Wisconsin, the upper midwest, and in the eastern United States apply large quantities of manure and include legumes in rotations, yet still apply fertilizer at rates nearly comparable to their neighbors who apply no manure and grow continuous row crops. Researchers in Wisconsin, Minnesota, Nebraska, and other states have documented farming systems that result in the soil receiving more than 100 pounds of nitrogen *in excess of crop needs* (Blackmer et al., 1989; Fox and Piekielek, 1988; Legg et al., 1989). Nitrate contamination of surface water and ground water occurs as a result.

The relationship between nitrogen application rates and environmental quality is becoming increasingly clear in many areas for many cropping systems. In some areas, there appears nearly a linear relationship between nitrate contamination levels in ground water and the magnitude of fertilizer applications in excess of crop needs.

In Nebraska's Central Platte Natural Resources District, data compiled by Dr. James Schepers, an ARS research scientist, sheds light on this relationship. Among 3,500 farms producing corn on over 200,000 acres--

- About 11 percent of corn acres received at least 100 pounds of N in excess of recommended rates.
- While producer yield goals were about 9 percent on average above actual yields, some individual farm yield goals were way above, and others well below, actual yield levels attained.
- Farmers applying at least 50 pounds of N per acre *less* than recommended rates had nitrate concentrations in their wells of about 10 mg/liter and achieved nearly or actually comparable yields to farmers applying far more N.
- Farmers applying recommended N rates had concentrations of N in their wells of about 18 mg/liter; farmers applying 150 pounds per acre in excess of recommended amounts had average N concentrations of 25 mg/liter.

Moreover, nitrate levels in many Nebraska wells have climbed steadily from about 2 to 5 mg/liter in the early 1960s to 10 to 20 mg/liter at the present time. "Insurance fertilization" is clearly a major cause, as evident in the results of yield trials from on-farm demonstration plots shown in Table 1.

The nitrogen management problem facing U.S. agriculture is not a result simply of the use of manure, or fertilizer, or legumes in rotations. It is the presence of nitrogen far in excess of a crop's needs. The solution is not to single out and punish one source of nitrogen, but rather to focus on balancing and managing the total supply of nitrogen in light of crop needs. There are a number of well-proven methods to accomplish this goal which will be assessed in crafting new water quality provisions for the next farm bill.

Options under review at the state and/or federal level to increase the efficiency of nitrogen use within agricultural production systems include:

- Limitations on fall applications of nitrogen fertilizers.
- Incentives for the planting of fall cover crops to tie up nitrogen over the winter.
- Restrictions on the total amount of nitrogen applied at any one time; encouragement for split applications.

Table 1. Nitrogen Application Rates and Corn Yield Levels in Selected Nebraska Counties, 1985 and 1986 Growing Seasons.

Year	Plot Location	Nitrogen Applied (pounds)	Yield/Acre (bushels)
1986	Hall County	185	173.6
		135*	170.3
		85	173.3
		0	167.8
1986	Buffalo County	160	159.8
		110*	161.6
		60	164.6
1986	Dawson County	200	150.4
		150*	151.8
		100	149.2
		50	151.4
1985	Merrick County	200	192
		146*	190
		70	180
1985	Hall County	190	135
		140*	140
		90	134
1985	Buffalo County	210	142
		160*	146
		110	141
1985	Dawson County	175	150
		125*	149
		75	148

* Recommended Amount
Source: Central Platte Natural Resources District Newsletter Vol. 3, No. 6-87, Grand Island, Neb., 1987.

• Development of cropping system nitrogen budgets that take into account all sources of nitrogen.

• Use in late spring of a newly developed nitrogen sidedress fertility test methodology to determine whether and how much additional fertilizer is required.

• Incentives for the careful and environmentally defensible collection, storage, and crop land application of manure.

• Establishment of more realistic yield goals.

A growing body of evidence suggests that improvements in water quality are attainable without new regulatory laws or restrictions (see Chapter 2, NRC, 1989, pages 98-114). In the case of nitrogen, the key goal for the nation must be to increase the portion of available nutrients from all sources taken up by plants, thereby reducing the portion that is lost by erosion, runoff, or leaching to surface water or ground water, or to the atmosphere through denitrification.

To reduce the flow of pesticides into surface water or downward into ground water in future years, farmers may need to pursue one or more alternative practices selected in an effort to use pesticides more judiciously or lessen pest pressure--and hence the need to use pesticides:

• Modifying cropping patterns and tillage practices to reduce the need for herbicides, improve root health, and control soil-borne insects.

• Seeking integrated pest management systems, plant cultivars resistant to pests, and other novel strategies that reduce pest pressure.

• Switching from relatively toxic pesticides known to leach to products that tend not to move so readily, or which are applied at much lower rates of application, or which pose less of a toxicological hazard.

• Improving the timing and placement of pesticides so that an adequate degree of control is obtained at lower rates of application.

Industrial manufacturing plants di
charging pollutants into waterways, t
air, or toxic waste dumps are requir
by various federal environmental laws
employ "best available technology"
limit the concentration of pollutants e
tering the ambient environment. F
farmers in the case of agrichemical a
organic nonpoint pollutants, there is
such corollary requirement. "Best ava
able technology" for water quality pr
tection from pesticides, for example,
generally thought of as some set
BMP's, or best management practice
Effective BMP's are available in ma
producing regions but are often appli
unevenly. Farm policy reform is bou
to address this issue, as will new laws
the state level.

Alternative agriculture: Bac to the future?

How the nation chooses to respond
a range of complex, interactive poli
issues will shape government's role
advancing sustainable agriculture. Pro
ress will occur most swiftly when n
policies take advantage of on-farm o
portunities to improve both econom
and environmental performance. Po
cies that appear onerous or unfair,
technically unsound or just too comp
cated, will generate much heat and lit
light. New policies designed to encou
age sustainable agriculture will be infl
enced, to some degree, by broader poli
issues and goals including the implic
tions of the current GATT negotiatio
the need to accommodate expanded pr
duction of many commodities, feder
budget constraints, and growing suppo
for environmental protection.

The American food industry has de
onstrated over the years remarkable
genuity and resiliency. Mother Natu
and market forces periodically deliv
devastating blows, although rarely wi
such vengeance as in the 1980s. Over t
years, these blows have caused chan
in the types of farming operations
certain regions and in the manageme
strategies followed on the land to redu
risk. Adjustments have often been tra
matic, yet the nation has rarely go

without adequate supplies of basic foodstuffs. Indeed, consumer food expenditures have steadily fallen as a percent of disposable income and surpluses have been the most persistent agricultural policy problem since the 1930s.

American agriculture is progressing into an era of change that could see the century's third major technological revolution in farming practices. The first occurred early this century as machines displaced the horses, mules, and oxen that broke the prairies and cleared the eastern hardwood forests. Scientific progress in the 1940s and 1950s made possible the second revolution, characterized by the new chemical- and energy-intensive technologies commonly used today in most major producing regions to exploit the yield potential of genetically improved plant varieties. And now another era of change appears on the horizon, an era in which the biological and ecological production potential of cropping and livestock systems is increased through renewed emphasis on the management--and improvement--of natural resource productivity.

The notion of alternative agriculture discussed in the recent NRC report is not a distinct set of practices. It is an approach to farming that is complex and technically sophisticated, heavily reliant on science and management skills. Its basic goal is to use nature as an ally and work within the limitations of the land and, when possible, to relax those limits by actually increasing the productivity of soil and reducing pest pressure and crop losses.

Sustainable production systems will depend on new knowledge and insight derived from careful observation and management of the biological foundations of farming systems. They will take years--even decades--to perfect, particularly in certain areas in which weeds, insects, and plant diseases are recurrent problems despite clever and careful use of all currently available cultural, chemical, and biological control technologies.

Moreover, farmers will never be able to rest on their laurels since the total demand for food here and abroad will steadily grow, increasing the pressure on farmers to harvest more food from each acre of land. The challenge is not just to maintain current crop production levels on a sustainable basis; we must also learn how to increase production levels and improve economic performance--on the farm and as a nation--while also decreasing agriculture's contribution to environmental problems.

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Swampbuster not protecting wetlands

Since the 1985 Farm Bill "swampbuster" provisions were passed, only 26 U.S. producers have actually lost benefits as a result of wetlands conversion, reports the National Wildlife Federation (NWF). Meanwhile, the Environmental Protection Agency estimates that over one million acres of wetlands have been destroyed since 1985, mostly as a result of agricultural activity, says NWF President Jay D. Hair.

Federation research shows that the majority of the 427 producers charged by the USDA with noncompliance have either appealed the charge or successfully challenged the determination of noncompliance, Hair said in a letter to USDA Secretary Clayton Yeutter on October 13, 1989. "Dramatic changes are needed in the legislation, the regulations, and the...attitude toward enforcement if swampbuster is to effectively preserve our wetland resources," Hair told Yeutter.

Organic certification act proposed in Senate

A bill outlining a national standard for organic food production was introduced in the U.S. Senate on November 16, 1989, by Senator Patrick Leahy of Vermont. The bill (S. 1986) establishes a USDA "organically produced" label for products meeting its standards. To avoid consumer confusion, it prohibits all other uses of the word "organic." The standard calls for ecologically sound production methods that do not involve the use of synthetic pesticides, annual inspection of each farm, periodic residue testing of products, and civil penalties for violations.

State programs may contain guidelines exceeding the minimum national standards if they are not inconsistent with the national requirements, not unduly burdensome on interstate commerce, and approved by the Secretary of Agriculture. The bill calls for a national meeting of organic producers and handlers to select a National Organic Promotion Board that would serve as a policymaking body for the industry, recommend production standards, and otherwise act as a voice for organic farming. The bill also calls for a pilot program to explore labeling for "low-input" farming products.

Copies of the bill, which was drafted by Leahy's staff, are available from his office (Room 328, Russell Office Building, U.S. Senate, Washington, DC 20510).

Environmental reform of agricultural policy in 1990 and beyond: Consider the source

Kenneth A. Cook

Abstract. *The environment will be a major issue during the 1990 Farm Bill reauthorization, with environmental reform efforts directed toward strengthening the conservation provisions of the 1985 Farm Bill, and expanding into new areas of water quality and food safety. The process will differ from the 1985 Farm Bill environmental reform experience in several important ways. In 1990, the policy ideas under discussion are more sweeping, the issues are more complex and controversial, scientific understanding is more ambiguous, technical capacity in the field is highly limited, and the farm policy environment is more volatile. Key environmental policy issues this year are the future size and purposes of the 1985 Conservation Reserve Program, and the strengthening of sodbuster, swampbuster and conservation compliance provisions enacted in 1985. Commodity program reforms that remove disincentives to crop rotations, and food safety issues will also top the environmental agenda. An Environmental Stewardship Program is proposed as a new approach to source reduction and pollution prevention. An ESP program might consist of 10-15 year contracts under which farmers are compensated to adopt environmentally sound practices such as crop rotations, reduced and more efficient use of agricultural chemicals, integrated pest management systems, and best management practices for water quality and food safety concerns.*

Key words: environmental problems, food safety, wildlife conservation, agricultural policy, ground water, research, extension, Alar

Introduction

One indication of the impact of the most recent round of environmental reform of agricultural policy in 1985 is the universally shared expectation that another round will follow in 1990.

Farm groups, commodity organizations, agricultural policymakers, researchers and analysts, journalists, and environmental and conservation interests of every description seem to take it for granted that the environment will be a major issue when Congress grapples with reauthorization of basic farm legislation. Beyond this seemingly total certainty that *something* will happen in 1990, uncertainty (very nearly as total) exists about exactly what that something will be.

This article begins with a very brief comparison of my impressions of the circumstances that led to the Conservation Title (XII) of the Food Security Act of 1985 (P.L. 99-198) with the circumstances in mid-to-late 1989. It then outlines several policy topics that deserve consideration in the 1990 Farm Bill debate and concludes with some guidelines for choosing among the many policy options likely to be floated from various sources in the coming months.

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1990 is not 1985

A steeper legislative learning curve

Resource conservation and enviro mental protection traditionally ha been marginal to mainstream farm po icy concerns of commodity prices, e ports, farm income, and credit. A certa amount of time is required for legislato to understand proposals to improve a riculture's environmental performan and to test these proposals with consti uents. Even the best of policy proposa can wither on the Capitol vine if t legislators have to bend too low to pluc them.

In both conceptual and procedur terms, the 1990 effort is behind the ty of schedule that seemed to work well establishing significant reforms in 198 By mid-1984, for example, key concep for the 1985 Bill - the Conservation R serve Program (CRP) and Sodbuster had been introduced, analyzed, a thoroughly debated in both the Hou and Senate agriculture committees a bills incorporating these ideas ha reached conference committee. Than to Senator Wyche Fowler's bill (S. 97 and the activity surrounding it, many the general concepts for promoting e vironmental protection and sustainab agriculture have been given greater a tention in Congress. The concepts, ho ever, remain very general; they are le than adequately concrete, are poor understood, and essentially unanalyz for their economic and other impact At the same time, the policy ideas bei discussed are much more sweeping scope than was the case in 1985.

Issues and goals are more complex and controversial

The major policy changes of the 1985 Food Security Act (FSA) focused on soil conservation on highly erodible lands and on wetlands conservation. The goals involved (1) reducing annual land idling programs by substituting long-term programs targeted to erodible land (the Conservation Reserve Program) and (2) using the leverage of USDA programs (commodity, credit, and storage) to encourage proper land stewardship (through sodbuster and swampbuster provisions).

Today the list of environmental issues for agriculture is much longer and more complex from a scientific and policy standpoint. It encompasses the quality of ground water and surface water, sustainable agriculture, food safety, and wildlife conservation, as well as all of the issues addressed in the FSA.

It goes without saying that soil erosion is a much less controversial and sensitive issue within the agricultural community than agrichemical usage or pollution. The latter issue loads the policy equation with the debate over the risk agrichemicals pose to public health, food safety, and the environment. Compared to 1985, environmental interests have staked out a much riskier technical and political terrain on which to operate in 1990 and beyond.

Scientific understanding of the issues is more ambiguous

This problem derives from the nature and number of the new issues, and presents a significant stumbling block. In the case of soil erosion, basic processes and the efficacy of solutions were reasonably well understood by 1984; some estimates of the damages caused by erosion had even been hazarded. We simply do not possess comparable knowledge about ground water pollution or soil quality and productivity under sustainable versus conventional farming systems, the health effects of minute traces of agrichemicals in food and drinking water, and so on down a rather long list. Scientific understanding of the magnitude and mechanisms of agrichemical contamination of ground water, for example, has been evolving steadily over the past decade, but we still do not know such fundamental things as how extensive the problem is or how rapidly it may be getting worse. We have uncomfortably vague notions about what we should do about it and where.

Technical capacity in the field is extremely limited

In presenting the case for the Conservation Reserve Program (CRP) and other soil conservation provisions in 1985, advocates could readily have argued that an infrastructure of people and technical know-how existed in the field that was capable of implementing fairly sweeping new soil conservation policies.

No such infrastructure exists, however, for dealing with ground water pollution, for example, or for providing technical information to farmers nationwide about how to make a transition from chemically intensive to reduced-input farming. Most SCS and extension service offices have little or no capability to provide farmers with technically and economically sound advice on such issues. It is, furthermore, unlikely that an infrastructure can be built very rapidly within the government to provide reliable information on how to reduce agrichemical use or begin a transition to organic farming.

The farm policy environment is more volatile

In 1985 the farm economy was on the ropes. Commodity prices were weak and commodity surpluses were mountainous; government outlays were on the rise; land prices were plummeting, pulling farmers and farm lenders with them. It was clear that the government would be intervening heavily in the farm sector in the years immediately following enactment of the 1985 Act. In 1990, we may see much tighter commodity markets; we are almost certain to see a farm economy that has improved, though at a terrible cost to society and the farm community in particular. It is riskier in 1989 than it was in 1985 to pursue any strategy of environmental reforms that is linked *in the short term* to the goal of reducing excess capacity in agriculture.

Some environmental policy issues for the 1990 Farm Bill

Review of Title XII

In what respects has the Conservation Title (XII) of 1985 succeeded, and in what respects has it failed? Both the novelty and scope of Title XII guarantee that it will receive considerable attention next year, and rightly so. Quite apart from its direct accomplishments out on the land, which are impressive, Title XII opened important new avenues for integrating conservation and environmental goals with agricultural policy. As a consequence, the successes or failures of Title XII have implications not only for the reform of the 1985 Act, but also for new initiatives in water quality, sustainable agriculture, and so forth.

Many of the critical questions about how well Title XII programs are working can only be answered in the field. The Soil and Water Conservation Society (SWCS), based in Ankeny, Iowa, recently concluded the first year of a major field evaluation of Title XII. Results of this study will strongly influence the fate of the 1990 Conservation Title.

Here is a brief survey of issues for four of the title's main provisions: Conservation Reserve Program, Sodbuster and Swampbuster, and Conservation Compliance.

Conservation Reserve Program. As of mid-1989, 30.6 million acres of highly erodible crop land had been enrolled in the CRP. The central questions to be explored in 1990 are these:

1. Should CRP enrollment be expanded? If so, by how much and for what purposes? I would offer several assumptions for approaching these questions.

--Production adjustment will be a continuing need in the early 1990s. Assuming the CRP is a cost-effective way to adjust production, expansion will be feasible, especially if program goals are modified. Under most scenarios, however, average bid rates will continue to rise, probably more rapidly than in sign-ups to date, and enrollment will climb more slowly.

--The amount of CRP expansion will

depend on the program's environmental goals. Environmental benefits clearly would be enhanced by targeting the program to deal with water quality and wetlands protection problems. In both instances, substantial benefits may be obtained by enrollment of relatively small areas. Defensible, workable targeting criteria remain to be developed for nationwide use, but it is clear that regional enrollment patterns would shift if water quality goals were emphasized.

--Expansion of the CRP as it is currently configured has limited potential for dealing with ground water contamination problems, except in selected situations, because contamination sources appear not to be concentrated. Particularly for ground water and surface water quality problems, long-term contracts that specify locally approved best management practices, instead of simple land conversion, may be an appropriate refinement of the CRP concept, for they could encourage management changes over much more extensive areas. Such plans could achieve some production adjustment goals and promote such management changes as lower chemical application rates, split applications of fertilizers, and more diversified crop rotations.

--Targeting expanded enrollment to improve wildlife conservation in wetlands and other types of habitat is likewise of interest. Targeting criteria have to be developed for habitat types other than wetlands, and wetlands criteria now in use must be reappraised.

2. What are the best ways to protect land enrolled in the CRP after contracts expire? Some assumptions:

--A considerable portion of the land currently enrolled will be brought back into crop production if no action is taken, notwithstanding the sodbuster provisions of Title XII.

--The most enduring conservation strategy for most of this land would combine economic use with adequate erosion control and habitat protection. Allowing economic use with payments, however, introduces equity questions for cattlemen and non-participating farmers.

--Long-term or permanent easements are more attractive to conservation activists and officials than they are likely to be to farmers, but these instruments deserve careful consideration, especially for high-priority lands.

--Limited public funds dictate the need for another layer of targeting criteria to determine which of the lands currently enrolled in the CRP should be prioritized for contract extensions, conserving-use plans, easements, or other policies to extend protection of CRP acreage.

--Protection of all or a portion of base acreage tied up in CRP contracts without requiring it to be planted after contracts expire may be a less potent CRP preservative than freezing base acreage generally within the commodity programs.

ESP: A CRP hybrid. The most promising and comprehensive approach to CRP reform may be to modify the program in order to encourage cropping and management changes that fall short of complete land use changes for both future and existing contracts. For example, a successor to the CRP, an Environmental Stewardship Program (ESP), might consist of 10-year or 15-year contracts under which farmers might be compensated to:

1. Adjust rotations *on the entire farm* in ways that control erosion yet reduce production of surplus crops and use of agrichemicals;

2. Modify the amount, timing, and method of agrichemical application to economize on inputs (use less overall) and improve input efficiency (use less per unit output of crop);

3. Adopt long-term integrated pest management systems which incorporate biological controls;

4. Modify farming practices to favor wildlife populations, habitat, and diversity;

5. Experiment with sustainable farming systems that incorporate alternative crops, promising pest control techniques, animal waste control methods, energy conservation programs, etc.;

6. Adopt Best Management Practices (BMPs) for water quality, food safety, or other environmental concerns, that include chemical-specific practices (reduced or no use of target herbicides, insecticides, and fungicides, for example).

ESP contracts (including those co verted from CRP) could contain all some of these provisions, depending site-specific environmental goals. Pa ment rates would be keyed primarily the impacts on production adjustme and farmers' costs, but could also refle reimbursement to farmers for the co of farming in ways that benefit societ In the case of crop rotations, for e ample, compensation might be muc lower, or might be eliminated altogethe for producers who shift from continuo corn to a corn-soybean rotation (such shift would be expected to reduce chem ical use but might increase erosion ha ard). Larger payments would be mad to producers who venture a more dra matic rotation shift and greater redu tions in agrichemicals. Producers wh already have such rotations and chem ical usage patterns might be eligible f mid-range payments and might als have their set-aside requirements a justed downward over time to reflect th production adjustment impact of the historical rotations.

It may be preferable to protect ba acreage, give production-adjustme credit for resource-conserving crop r tations, allow greater flexibility in plan ing decisions, or attempt other reform through an ESP type of approach i stead of authorizing broad changes the overall commodity programs (s Commodity Program Reforms, below A long-term contract approach like ES offers these advantages over commodi program reform: It is a long-term mec anism less susceptible to vicissitudes the market; it can be targeted geograp ically, by type of environmental pro lem, or by other criteria; it provides greater measure of predictability farmers and USDA program manage the program could be opened to broader range of farms and farm ente prises, including producers of non-pr gram crops and potentially livesto operations; impacts on farmers and t environment would be easier to measu and evaluate.

Sodbuster and swampbuster. Und these policies, farmers must abide by ce tain conservation guidelines in the u of highly erodible land or wetlands risk losing eligibility for a wide range

USDA programs, including commodity programs. The central questions here have to do with how affected lands were identified in the field and with enforcement of penalties where violations have been alleged or proven.

Farmers have raised questions about the criteria and procedures for defining wetlands, the "drop dead" penalty (total loss of benefits for any degree of infraction), and perceived inconsistencies between sodbuster and swampbuster regarding the grandfather clause that is linked to cropping history. Conservationists have questioned the rigor and adequacy of enforcement.

Conservation compliance. This provision requires farmers to have a conservation plan for any highly erodible land they farm by the end of 1989 and to implement that plan fully by the end of 1994 in order to remain eligible for most USDA programs. Questions related to this provision include:

--How much erosion reduction is being required of farmers, what are they being required to do, when will they do it, and what will it cost them?

--How will compliance be enforced?

--Is the compliance concept of planning for specific conservation goals adaptable to other conservation or environmental problems, such as nonpoint source pollution? What form should the adaptation take?

If reviews of sodbuster, swampbuster, and conservation compliance reveal that these policies are not meeting Congressional intent, two general issues that have repeatedly arisen in the literature pertaining to Title XII will have to be reexamined:

--Changes in administrative procedures and institutional roles, including the need to include other government agencies in policy implementation and the possibility of a revised planning and implementation schedule;

--The potential of alternative means for reducing the adverse impacts of commodity programs on soil and wetlands conservation, such as reduction of farm program benefits, or decoupling income support from production.

Reform of USDA commodity programs

Crop programs. It is hardly surprising that advocates of sustainable agriculture and of environmental reform of agricultural policy in general have identified USDA commodity programs as a major barrier to more "sustainable" farming systems. Because the production of certain of these program crops - notably corn, wheat, cotton, and rice - remains in chronic surplus, opportunity exists to reduce production in ways that benefit the environment and serve production adjustment goals. Similar logic underlies the CRP and other provisions of Title XII.

As was the case with the provisions of the Conservation Title in 1985, any attempt to modify longstanding agricultural programs immediately raises problems of equity and efficiency. A substantial number of farmers, for example, already utilize fairly diversified crop rotations, incorporating legumes and small grains with corn, soybeans, and other crops. Under current policies these farmers are penalized, in terms of government support, relative to neighbors who have planted program crops fence row to fence row. Considerations of equity make it a matter of some interest to either remove or reduce those penalties; some people believe it is only fair to actually reward cropping patterns that can be considered "resource conserving" (a term employed in S. 970), in effect conferring program status on crops that do not now have it. It can also be argued that unless the playing field of farm programs is leveled, more and more producers will succumb to the economic pressures to simplify rotations in favor of program crops.

From the standpoint of environmental goals, however, rewarding the good guys is inherently less efficient than policies aimed at the farmers who are doing the "wrong" things: those who are growing continuous corn, for example, and applying the high levels of nitrogen and pesticides common to that cropping regime. Paying a farmer *to continue rotating crops* may be the equitable thing to do; paying a farmer *to begin rotating crops* (switching from continuous corn, for instance) is the efficient thing to do, simply because it can result in major reductions in chemical use. The alternative, of course, is to penalize farming practices that result in resource or environmental degradation.

The equity-efficiency arguments carry over to fiscal considerations as well. Farmers whose rotations have the effect of holding down production of surplus crops are already doing the right thing, but from the perspective of USDA and the Office of Management and Budget, there is no need to pay them and nothing to gain by doing so. Farmers who are maximizing their production of surplus crops, on the other hand, are the principle targets of USDA programs and the main recipients of program benefits.

One defensible way to resolve these conflicts may be to gradually increase production adjustment requirements for producers who are relatively more specialized in terms of program crops, while lowering it for those who have "resource-conserving" cropping systems. Traditionally, set-aside requirements are identical for all producers, regardless of their size or degree of specialization. This concept might be termed "variable set-aside," and its parameters might be established by a combined index of commodity specialization and scale of production.

At the same time, it seems that the most worthwhile way to change commodity program incentives is to target them to farms on which both production adjustment and environmental goals will be realized. This is how the CRP has been targeted in the past, but there is an important distinction. Land enrolled in the CRP has not been available for economic use to date. Most reforms for sustainable agriculture, however, presume economic use and would therefore represent an equity and competition problem. Any farmer paid to make the transition to a more diverse rotation would by definition represent subsidized competition for farmers who have had such rotations all along. Analysis of impacts on producers of cattle, forage, and small grains, therefore, is essential in any consideration of broad commodity program reform.

As is the case for sustainable or alternative farming generally, crop rotations, too, present a continuum. In the Corn Belt, for example, the continuum

ranges from continuous corn, to corn alternating with soybeans, to myriad rotations incorporating legumes, grasses, and small grains. Environmental gains can accrue all along this continuum, not just at the fully diversified end of it. A shift from continuous corn to corn and soybeans, for example, can significantly reduce nitrogen and insecticide use. For many commodities and regions, particularly in dryland areas and in the southeastern United States, fewer farm enterprises can readily substitute for prevailing ones.

Other things being equal, environmental gains will be significantly greater for any policy when it can be targeted to reduce an identifiable environmental risk. Continuous corn production poses a more serious or immediate risk to ground water in some areas, for example, than it poses in others. Likewise, reductions in the use of some herbicides will reduce the threat of ground water contamination more than reductions in the use of other herbicides.

Given these complexities, it may be more equitable and efficacious (as discussed earlier) to improve upon the CRP concept, perhaps along the lines of ESP, than to attempt wholesale, untargeted reform of constantly changing commodity programs. For all its weaknesses, the CRP concept appears to have fundamental advantages over almost any likely reforms of the commodity programs.

Dairy program. Under USDA's current legal interpretation, the conservation provisions of the 1985 FSA do not apply to government payments made under the dairy price support program because those payments are made to milk-processing entities, not directly to the farmers who might potentially be sodbuster or swampbuster violators. One reasonable question for the 1990 Bill is whether some attempt should be made to extend these provisions to the dairy sector. It may also be worth examining how the dairy program might be reformed to deal with other environmental and public health aspects of milk production - notably with animal waste disposal, a major water quality problem in many dairy regions - or excessive use of subtherapeutic doses of antibiotics.

Source reduction strategy

Many of the environmental problems outlined earlier are caused by farm practices that are excessive or inefficient *in environmental* terms (and often in economic terms as well). Ground water and surface water contamination by nitrates, for example, results from inefficient and excessive use of synthetic fertilizers or, in some cases, manure. Soil erosion derives from excessive exposure of the soil surface to wind and water. One can solve these problems by dealing with them after they have occurred. Building a sediment catchment for soil erosion, planting a buffer strip of grass alongside a stream to trap sediment and nutrients in water runoff, or adding a filter to a tap or household water system, are examples of *post hoc* pollution control. A more promising approach is to reduce the generation of pollutants in the first place.

The concept of source or waste reduction has received most attention in the field of industrial pollution control. It simply means "cutting the generation, emission, or discharge of hazardous waste at the source to avoid its handling, treatment, or disposal."[1] (Source reduction also helps avoid pollution itself, of course, reducing the attendant health or environmental risks.) The concept might be adapted to agriculture as follows: "cutting the generation, emission, or discharge of agricultural pollutants or waste through modification of agricultural production systems and practices."

One of the appeals of source reduction as a policy theme is that policy objectives can be readily identified and, with some work, even quantified. The main task is to identify and describe the type and magnitude of the "waste" or pollution one seeks to reduce or eliminate. In agriculture some of the candidates are obvious: nutrients, pesticides, and animal wastes that degrade water quality, create human health risks, threaten wildlife, or pose other environmental problems; excessive soil erosion that compromises land productivity or surface wate farming systems that generate gree house gases, and so on. If "waste" anything in a production system or fir product that is unnecessary or undes able from a health or environmen standpoint, then pesticide residues food and excessive use of growth ho mones or pharmaceuticals in livesto could be considered source reducti targets.

Source reduction implies applicati of the same environmental criteria organic farming systems, which are c pable of generating large volumes waste and pollution, that would app to chemically intensive farming system On the whole, of course, a source r duction strategy would tend to strongly biased in favor of agricultur production systems that avoid heavy u of potential pollutants. Indeed, organ farming could be seen as the ideal sour reduction system where agrichemica are concerned. In that sense, source r duction as a guiding concept for agr cultural policy has many of th advantages of "low input" or "sustai able" agriculture, with few of the de nitional disadvantages of those term Properly conceived, source reducti has the added advantage that it reduc the likelihood that the solution to on environmental problem will make a other worse. In agriculture, howeve some of the tradeoffs are not yet clear identified. Reductions in herbicide u that require increased cultivation ma exacerbate soil erosion problems an through increased field disturbanc compromise wildlife habitat.

The most promising target for source reduction strategy in contemp rary agriculture is the use of agricultur chemicals in plant nutrition and pe control. The key components of a su cessful source reduction strategy f agrichemicals are: (1) sound informati on agrichemicals usage, environmen fate, and relative risks of chemicals a usage patterns on environment and h man health; (2) economically and tec nically feasible adjustments to farmi systems to reduce or substitute use these materials; (3) research and tec nical assistance capacity to suppo changes in farming systems; (4) a

[1]Northeast-Midwest Coalition. "The Hazardous Waste Reduction Act [of 1987]." Report, 100th Congress. June 30, 1987, p. 9. The definition is attributed to the Office of Technology Assessment.

vorable policy framework which encourages source reduction to minimize risk, ideally by setting quantitative goals, while safeguarding against undesirable secondary effects or tradeoffs. These components could be adopted in the context of an Environmental Stewardship Program.

Market channels: Harnessing the demand side

The recent controversy over Alar demonstrated, among other things, the potential power of consumers to prompt adjustments in agricultural production systems. Indeed, that may be the most lasting effect of the entire episode. The lesson for the 1990 Farm Bill is that the time has come to harness the consumer's demand for safer foods by widening the marketing channels for foods produced with no or few chemicals. One way to do this would be to further segment food grading standards to accommodate "alternative" foods.

Two general categories seem worth examining. One is organic foods, of course, on which no synthetic pesticides, preservatives, or other chemicals have been used. A second category, provisionally termed "low risk," would be comprised of foods produced without the use of chemicals of regulatory concern to EPA or state regulatory agencies; use of some pesticides would be allowed, as would the use of synthetic fertilizers. In the supermarket, both of these categories would be represented by symbols, much as the current grading system is represented. For both organic and the low-risk categories, farmers probably would have to enter into some form of management agreement, perhaps with the state department of agriculture, to back their certification as organic or "low risk" food producers with documentation and periodic inspections. Farmers would have the option of accepting these terms and producing for the newly enlarged specialty market for organic and "low risk" foods or of continuing to produce as before for normal marketing channels. Consumers would have parallel choices at their end. With modifications, both of these new grading categories would be adaptable to livestock production.

Such a new grading/marketing scheme could be authorized through the next farm bill. In fact, it is potentially the most powerful and direct way to significantly influence chemical use patterns on commodities not covered by USDA subsidy programs - and these chemicals and uses are of great importance in the overall impact chemicals have on the environment and human health. Ideally, consumer education would also receive more emphasis through expansion of existing programs or authorization of new ones.

Extension of FSA provisions to other farm lenders

Sodbuster, swampbuster, and conservation compliance provisions of the 1985 FSA provide stewardship leverage in proportion to (1) adequacy of enforcement and (2) degree of farmer participation in USDA commodity, credit, and other programs. The second factor, of course, is largely a function of the shape commodity markets are in, with the important exception of ownership and operating loans made or guaranteed by the Farmers Home Administration (FmHA), the so-called lender of last resort for farmers. Such loans are made year in and year out, regardless of market conditions, to qualified borrowers.

In 1987 Sen. Wyche Fowler proposed that lenders benefiting from farm credit assistance legislation be required to play by the same rules that FmHA plays by with respect to sodbuster and swampbuster. In effect, all Farm Credit System entities (the giant in farm credit) and any bank or insurance company participating in the newly authorized secondary market for farm real estate loans would have been required to ensure that its borrowers did not drain wetlands or improperly cultivate highly erodible lands. As things now stand, if a bull market returns, the commodity programs will atrophy (probably temporarily); and FCS and other lenders will be free to make loans that lead to sodbusting, swampbusting, and very likely to excess crop production, much as they did during the 1970s and early 1980s. Sen. Fowler's proposal to extend sodbuster and swampbuster to these lenders failed in 1987; but the concept merits serious consideration in 1990, for it would mend a major hole in the fabric of existing conservation policy.

Research and extension policies and programs

The research and extension functions of the agricultural establishment must undergo fundamental reforms if the environmental performance of U.S. agriculture is to be improved. Major increases in research funding are needed to improve biological pest control, examine the environmental potential of crop rotations and alternative crops, understand waste and pollution phenomenon, and achieve many other environmental objectives in agriculture. The place to begin working for these and kindred reforms is to modify basic "organic" statutory language for agricultural institutions, to place environmental objectives on par with all other research and extension missions and goals. On the funding question in particular, efforts should be made to control and rechannel agricultural research funds received from private sources by any land grant institution that also receives government funding. All such funds should be "bundled" by the recipient institution, not allowed to go to specific projects; and the disposition of the bundle should be overseen in such a way as to ensure that environmental and sustainable agriculture objectives are given the highest priority.

Guidelines for policy reform in 1990

Several additional questions might be asked of both individual policy ideas or package proposals for environmental reform of agricultural policy in 1990.

1. How much will the proposal cost, and where will the money come from? Example: How much would it cost to confer commodity program status on production of legumes or legume-small grain mixtures? Will funding come via transfers from existing commodity programs or merely compete with them, increasing outlays?

2. For packages, is more than one proposal competing for the same funding or attempting to solve the same problem? Would multi-year set-asides compete with the CRP for land? Would a requirement for full-season vegetative cover on all set-aside land and associated payments compete with commodity program reforms or the CRP for both funds and land?

3. Is the policy idea targeted to a specific environmental problem? Can it be? Can policy goals be quantified? Can progress be measured once the policy is implemented?

4. Is the policy proposed for nationwide adoption based on the experience in only one part of the country? For example, policies attempting to affect set-aside status in humid regions often can be counterproductive or economically unsound in dryland areas.

5. Is participation or policy coverage likely to be significant given the incentives offered, the funding available, or the implementation capacity in the field?

6. Are the timetables reasonable given the nature of the problem and implementation capacity?

7. Are the policies capable of enduring wide swings in market conditions and government intervention?

8. Will the policies help some farmers at the expense of other farmers?

9. What are the enforcement costs and bureaucratic workload implications of the policy?

This is by no means an exhaustive list of questions to be asked about emerging policy proposals. Even so, it is much more exhaustive than the list farm interests typically face when they propose ideas that will cost the government tens of billions of dollars in a matter of a few years. For good or ill, environmental reforms of agriculture must pass stringent tests to compete in the farm policy arena; it is just as well that those proposing policy reform administer those tests first.

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Maine passes food safety labeling laws

After January 1, 1990, grocery stores in Maine will have to post a prominent sign if produce has been treated with chemicals after harvest, says the Maine Organic Farmers and Gardeners Association. The new Maine Post Harvest Treatment Labeling Law, advocated by MOFGA, also requires stores to label produce that has not been treated after harvest and to answer consumer inquiries about types of treatment within 48 hours.

Effective September 30, 1990, another label is mandated to show the country of origin on produce that comes from countries that allow uses of pesticides banned in the United States. Further, the Maine Department of Agriculture is required to carry out an educational program to help consumers know which countries allow such uses and what produce is likely to be affected. "If Maine consumers decide on the basis of this new information to buy more homegrown produce, all Maine farmers will benefit," says MOFGA.

Organic farmers set up national organization

The Organic Farmers Association Council (OFAC) met in December, 1989, to organize itself as a national coalition that will build unity in addressing organic food legislation issues. Allen Moody, a Kansas organic producer, was named spokesperson for the group. Tom Forster of Washington Tilth and Judith Gillan of OFPANA are other members of the executive steering committee. For more information on the new organization, contact Moody at RR 1, Box 132, Dodge City, KS 67801.

Governors recommend environmental reserve program

The National Governors Association has called for creation of an Environmental Conservation Acreage Reserve Program that would expand the current Conserve Reserve to include wetlands, endangered species habitat, and other areas that affect water quality. It also supports incentives for planting windbreaks, restoring wetlands, and creating new wetlands to control nonpoint source pollution.

Natural food sales up to $3.5 billion in 1988

Total sales of natural food products stood at $3.5 billion in 1988, about double the amount sold in 1979, says a report from New Hope Communications of Boulder, Colorado. Sales of organic fruit and vegetables in natural foods stores nearly quadrupled between 1979 and 1988, rising from $21 million to $78 million. Other organic food sales grew in comparable amounts. Sales of chemical-free meat jumped from $4 million in 1979 to $54 million in 1988. Natural frozen food sales rose from $62 million to $110 million.

Better cosmetic quality, more consistent availability, and strong marketing are the key reasons for the long-term growth, the report says. *The Natural Product Market* is a 200-page publication with information on regulation and legislation, acquisitions, and sales figures. It is $975 from New Hope Communications, Research Division, 1029 NW 23rd Avenue, Suite 300, Portland, OR 97210. New Hope Communications is the publisher of *Natural Foods Merchandiser.*

Converting stewardship values into policy: The mission of the 1990 Farm Bill

Ron Kroese

Abstract. *Farmers committed to the overall goal of sustainability in agriculture have banded together to support legislative action favorable to that goal. Specific objectives relate to addition of organic amendments to soils to improve fertility, avoidance of excessive use of pesticides and synthetic fertilizers, crop rotation, species diversity among crops, protection of wildlife habitats, and support of family-operated farms. Currently applicable legislation is believed to be unfavorable to some of these objectives and needs modification.*

Key words: farm sustainability, organic soil amendments, soil fertility, decreased pesticides, less synthetic fertilizer, crop diversity, food safety, water safety, tax reform, credit incentives

Translating the wisdom and ethical values that guide farmers committed to sustainable farming into public policies that will reinforce those values should be the goal of policy reform for the 1990 Farm Bill. Under current federal farm policy, farmers committed to raising crops and livestock in as ecologically sound a manner as is possible frequently find themselves at odds with federal programs. Too often those programs encourage specialization and monocropping, thereby rewarding resource extraction. Conscientious farmers must sacrifice the income security offered by government commodity programs if they are to work the land in a manner that reflects the common sense wisdom they've acquired through years of careful husbandry.

Whether federal programs that reinforce land and water stewardship can be achieved, when stewardship values are often at odds with the profit-first ethos of the culture at large, remains an open question. It is clear, however, that unless policies reflect the values of stewardship an agriculture that is truly sustainable will not be achieved.

What are those values? To discover them, the Land Stewardship Project has looked to farmers who for many years have struggled to live a stewardship ethic. These farmers are linked by their commitment to one overriding principle: A devotion to leaving their land in better condition than when they began farming it. For example, several of the farmers interviewed for LSP's book, *Excellence in Agriculture* (1987), pointed with pride to once-brown knolls in their fields that are now black with rich topsoil or dug their hands into fluffy soil in which the percentage of organic matter had increased during their tenure on the land.

In addition to an underyling commitment to soil conservation, the stewardship farmers surveyed by the Land Stewardship Project view the soil on their farms not merely as a physical medium, but as a living biotic system that must be carefully maintained. They value diversity and rotate their crops, and most of them integrate livestock into their operations. They consider animal manure to be a valuable resource rather than a waste product, and they prefer animal manure and green manures as sources of soil fertility. They are distrustful of synthetic pesticides and use them reluctantly, if at all. They are concerned about the safety of the drinking water on their farms and worry about whether products put on the land eventually end up in the water.

Stewardship farmers love the wildlife their farms nurture and judge the environmental health of their farms by the amount and vitality of the wildlife they see on their land. They are concerned about the decline of their rural communities as fewer and fewer farmers own and work the land. They would rather have neighbors than their neighbors' land. They recognize limits on the amount of land they can properly manage. They are humble about their role in relation to the natural systems with which they work on their farms.

A final point, more an attitude than a value, is an acquired piece of wisdom: Most stewardship farmers tend to be distrustful of government farm programs, since most of these farmers cannot fit the way they believe they ought to farm into the confines of federal commodity program requirements. Faced with this problem, they make the best of it with little or no government support, surviving economically through hard work and skillful management and increasingly by finding marketing niches for the quality food they produce.

While there are thousands of farmers who have made an ethical decision not to alter their farming systems in order to participate in government programs, there are certainly hundreds of thousands of farmers who are unhappy with the compromises they must make to participate but choose to do so out of economic considerations.

Presented at Institute for Alternative Agriculture Symposium on Sustainable Agriculture, February 28, 1989, Washington, DC.

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The 1990 Farm Bill offers the opportunity to implement a range of policy reforms that would reinforce stewardship values and set U.S. agriculture on a course toward long-term sustainability for the 21st century. Through this bill changes could be initiated in commodity, research, and resource conservation programs that would remove existing impediments and build in new incentives to the adoption of sustainable farming practices. Tax reform and credit incentives are also needed to remove inequities and increase opportunities for producers, especially beginning farmers, committed to low-input sustainable approaches. Moreover, a federal commitment must be made to reviving enforcement of anti-trust laws to make it possible for small- and moderate-scale farmers to compete with larger scale operations, especially in the livestock industry.

In an attempt to make at least a portion of this agenda a reality, a group of twelve primarily Midwestern farm and rural advocacy organizations joined forces in 1989 to form the Sustainable Agriculture Coalition. Although the overall agendas of these organizations vary, they are united by a conviction that federal farm programs should be directed to family-sized farms that demonstrate a commitment to conservation and stewardship.

The Coalition's organizations, all of which are involved in grassroots efforts to foster the broader adoption of sustainable agriculture in their respective regions, include: The Alternative Energy Resources Organization (Montana), the Center for Rural Affairs (Nebraska), the Illinois Sustainable Agriculture Society, The Kansas Rural Center, the Land Stewardship Project (Minnesota), the Michael Fields Institute (Wisconsin), the Minnesota Food Association, the Minnesota Project, the Nebraska Sustainable Agriculture Society, the Northern Plains Sustainable Agriculture Society (North Dakota), the Organic Growers and Buyers (Minnesota), and the Wisconsin Rural Development Center. Through a variety of policy development activities in their own home states, and aided by a small staff in Washington, DC, the Coalition members hope to translate the recommendations from practicing low-input, sustainable farmers into federal policy initiatives.

Working with a larger loosely knit Sustainable Agriculture Working Group that includes representatives from farm and environmental groups around the country, the Coalition has prepared a series of brief option papers on the topics of USDA commodity programs, research needs, conservation, trade, and water protection strategies. For example, the commodity paper includes a recommendation that flexibility be built into the base acreage program by allowing farmers to plant up to 40 percent of farm program base acres to a soil-building legume or legume/small-grain mixture while retaining base history and receiving deficiency payments. The papers also call for multi-year set-asides with required conservation practices, the redetermination of base acres for farms according to the suitability of the land to grow the respective program crops, and targeting farm program benefits to moderate-sized family farms by setting a limit on the volume of production that would be supported by the farm program.

The paper on research calls for initiatives that will strengthen the competitive position of small- and moderate-sized farms, maximize the number of ec nomic opportunities in agriculture a farm communities, enhance hum health, reduce input costs, protect t environment, and preserve natural r sources for future generations.

All of the Working Group's poli proposals seek to foster the adoption an agricultural structure based on fa ily-sized farms and sustainable farmi approaches that would enhance the na ural resource base, promote opportuni in family farming and in farm comm nities, produce quality food, and prote human health. Although more work needed to examine the changes that w be needed in the government's delive system to institute these programs a to study the budgetary implications these proposals, the recommendatio make clear that it is possible to transla the values of stewardship farmers in policy. Doing so not only would repla the disincentives for land stewardsh with some rewards for individual far ers, but would create a long-term fram work for ecologically sound cropla use that would benefit farm communiti and the nation and its future as a who

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Native crops research in New Mexico

Native crops traditionally grown in low-technology situations may have something to offer both the diet and the economy of North Americans. In New Mexico, LISA funding is helping Jose Ballon, a specialist in the traditional grain called "quenua," test the yields for several traditional crops in diverse environments.

Bean varieties from the Hopi Indians and the Incas of South America are being compared for root growth and yields in irrigated and non-irrigated plots. Four types of quenua, a South American grain that grows well in high elevations, are being tested for adaptation and nutritional values. A South American variety of potato that is frost resistant, a carrot-like tuber, and several varieties of amaranth are other crops being evaluated in the project.

The research is coordinated by Talavaya, a private nonprofit organization in Santa Fe, which was awarded the 1985 Environmental Leadership Award by the United Nations for pioneering work in the preservation of native crops compatible with low-input growing techniques.

COMMENTARY

How organic producers can make classical biological control work for them

R. G. Van Driesche

Abstract. *Organic producers have traditionally understood the value of conserving the natural enemies of the pests of the crops they grow. An equal appreciation of the value of importing new species of natural enemies is also needed. Given this understanding, the interests of organic farmers could then be promoted by efforts to stimulate greater activity by government agencies in charge of such importations. Furthermore, the focus of such importations could be altered to target more precisely pests of crops most commonly grown by organic producers. This would benefit organic farmers by permanently solving or greatly reducing the intensity of problems from many introduced crop pests. The potential benefit of a coordinated federal and state program of classical biological control could be very large for organic farmers. There is an increasing interest nationwide in expanding the use of classical biological controls. Organic producers now have the opportunity to add their influence to this trend to reshape the country's pest control agenda away from chemicals and toward biological controls and to focus this at least in part on those pests of greatest concern to organic producers. To do so, however, organic producers will have to learn a new lesson, i.e., the difference between native and imported pests and the value of importation as a means to control the latter.*

Key words: classical biological control, alternative agriculture, introduced pests, parasites, predators, public policy

Introduction

Organic agriculture seeks to minimize insect pest problems by creating conditions favorable to naturally occurring sources of mortality such as parasites, predators, and more pest-resistant plants. This is done by avoiding practices such as pesticide application, use of concentrated fertilizers, and planting large-scale monocultures that can create pest problems or make existing ones worse. This approach to pest control is a form of biological control and is referred to as *natural enemy conservation*. Its goal is to provide an environment in which those things that repress or kill pests can flourish. Entomological research has shown this to be a sound strategy in many cases, contributing toward the control of such pests as apple blotch leafminer (Van Driesche and Taub, 1983), Colorado potato beetle (Hazzard et al., 1990), two-spotted spider mite (Prokopy et al., 1990), and European corn borer (Coll and Botrell, unpublished data).

Some insect species, however, fail to respond to natural enemy conservation practices. Cabbage maggot, Russian wheat aphid, green peach aphid, birch leafminer, euonymus scale, and others continue to cause significant losses even under organic farm management. Why? A common feature of many of these pests is that they are not native to North America, but rather have been introduced from other countries. Why is this important?

Native versus introduced pests

Parasites, predators, and diseases--i.e., natural enemies--are important checks on the growth of many insect populations, especially species that are soft bodied or sessile or are found in exposed locations like aphids, scales, mealybugs, caterpillars, eggs of many moths, etc. Natural enemies tend to be less significant for insects whose lives are spent in protected locations, as for example, borers deep inside woody plant tissue or grubs living in soil. The general importance of natural enemies, however, for a broad range of insects has been well documented (DeBach, 1964; Huffaker and Messenger, 1976). Natural enemies of insects, however, are often left behind when insects spread long distances to new locations due to natural forces or, more often, because of human movement of goods. This happens because very often only small numbers of a pest, often in only one or two of the various possible life stages, are present in the set

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of individuals that by chance gets moved to the new location. Nursery plants, for example, shipped from Asia to the U.S. (or vice versa) may inadvertently bear a few eggs of a lacebug, a few aphids or whiteflies, or a few scales. These may by chance all be unparasitized, healthy individuals. If so, the entire new population in the U.S. will be parasite and disease free. This will raise the ability of the population to increase, leading to higher densities. The species, which may have been rare and unimportant in its homeland, becomes a pest where it is introduced! Local species of natural enemies that attack related species may attack the invader and help to suppress its population size to some degree. However, this is very often insufficient to prevent the invading species from reaching pest levels. Why? The reason for this is that, while natural enemies which have broad ranges of prey or hosts are important in resisting population increases of broad sets of insects, their action is unfocused and in general such species do not respond efficiently to outbreaks of individual pest species. It is rather most often precisely those natural enemies that are highly specialized and attack only a few species that are most effective in suppressing pests. Thus, of existing native natural enemies, the ones most likely to attack a new invading species are the generalists, the ones least likely to provide effective control. Invading species thus often escape their specialist natural enemies and in return become attacked by less effective generalists. For this reason, invading species often become major pests.

That introduced species tend to dominate commodity pest lists in North America is illustrated by a study of pests of importance on crops in Massachusetts (Van Driesche and Carey, 1987). Of 109 species whose origins were known, 49 percent were introduced. Crops having the highest proportions of introduced species were woody ornamentals and vegetables, both of which are made up of many introduced plant species. The crop with the lowest proportion of introduced pests was cranberries (27 percent), a native plant (Table 1).

Given then that many of the pests which organic producers must control are going to be introduced species for which existing native natural enemies are likely to be ineffective, how can such pests best be controlled if chemicals are not to be used?

Natural enemy conservation and natural enemy introduction--How do they differ

Organic farming's reliance on existing biological control agents to control pests rests on the belief that effective natural enemies exist locally and potentially can be made to flourish given the right environment. As mentioned above, this is likely to be true for many native species of pests and likely to not be the case for many introduced species of pests.

Conservation methods

To conserve natural enemies, farmers must avoid doing harm to the beneficial species they wish to encourage. Pesticides are the major force destroying natural enemies. Indeed, in conventional agriculture many species have reached pest status only because their natural enemies have been destroyed. These so-called induced pests are not truly pests but have become so because of the pattern of pesticide use. DeBach (1974) cites examples of such pest creation in the California citrus industry, including outbreaks of various scales and spider mites caused by the use of broad spectrum organochlorine pesticides. In the northeast U.S., outbreaks of apple blotch leafminer and Comstock mealybug are other recent examples (Weires, 198
Organic producers do not, by definiti
use synthetic pesticides. While t
greatly reduces the likelihood of su
problems, it does not eliminate them
tirely. Some chemicals approved for
in organic agriculture still have the
tential to cause pest outbreaks by
stroying natural enemies. Sulfur,
example, is used on fruit to control pl
diseases but is very damaging to p
daceous mites and entomopathoge
fungi. Use of sulfur may cause spi
mite outbreaks.

Other conditions that may damage
fective action by natural enemies inclu
some species of ants and, in dry are
excessive levels of road dust on folia
Some ants tend honeydew-producing
sects like scales and whiteflies and
fend them from attack by parasit
Dusty leaves make parasites less eff
tive because parasites spend more ti
grooming and less time laying eg
They may abandon dusty sites m
readily.

Positive things that farmers can do
encourage natural enemies include
provision of alternative hosts, foods, a
sheltering sites. In California, for
ample, the grape leafhopper is control
by an egg parasite, but only if blackb
ries are found adjacent to the vineyar
This is because another species of
afhopper is found on blackberries t
the parasite requires to maintain its p
ulation on a year-round basis (Doutt a
Nakata, 1973; Williams, 1984). Crop
tations may be significant if natural e
mies build up on one crop and then
available the following season in
hanced numbers to attack a pest in

Table 1. Numbers of introduced versus native pest insects or mites on crops in Massachusetts[1]

Crop	Number of Species			% Introduc
	Introduced	Native	Unknown	
Apple	4	4	7	50%
Small fruits	7	8	8	47%
Cranberry	4	11	3	27%
Vegetables	9	7	2	56%
Forage	5	5	0	50%
Greenhouse	5	8	5	39%
Woody ornamentals	19	13	1	54%

[1]Taken from Van Driesche and Carey (1987).
[2]Percentage of introduced species is calculated as the ratio of introduced species to introduced plus na
species, leaving those of unknown origin out of the calculation.

second crop. This is thought to be the case for the coccinellid *Coleomeqilla maculata* (DeGeer), which feeds on corn pollen and Colorado potato beetle eggs. Rotation of potatoes and corn may enhance levels of this ladybird beetle and help suppress the Colorado potato beetle (Ferro, unpublished data). Field size and distance to non-cultivated sites suitable for overwintering of natural enemies are also important features of farms that influence the effectiveness of natural enemies. Boller et al. (1988), for example, report that *Typhlodromus pyri* (Scheuten), the major mite predator in Swiss vineyards, depends on adjacent hedges as overwintering refuges.

The introduction strategy

For introduced species of pests that lack effective natural enemies in the local area, none of the above conservation techniques will solve the problem. In such cases the answer lies in solving the problem not at the farm level but at the community level (state or county) through the scientific importation of the missing specialized natural enemies that attack the pest in its homeland. This approach is called classical biological control and has been practiced successfully for over 100 years. In excess of 157 pest species have been the targets of classical biological control projects, and of these 20 percent have been so successful that the insects involved are no longer considered pests. Substantial control in an additional 47 percent of projects has also been achieved (Laing and Hamai, 1976). Pests such as the cottony cushion scale (citrus), the alfalfa weevil (alfalfa), the Rhodesgrass mealybug (pasture), the cereal leaf beetle (oats), the pea aphid (alfalfa, field peas), the apple mealybug and the browntail moth (deciduous forest) are examples of pests that have been controlled to such a degree that the problems they once caused are largely forgotten.

Classical biological control projects require the services of trained entomologists specializing in biological control. All importations must be done only after obtaining approval from governmental bodies charged with excluding plant pests. All importations must be made to approved quarantine laboratories where material will be examined carefully to screen out any harmful organisms that may accidentally be included in field-collected material. Importation projects start when a pest is identified as suitable for attack through importation of new species of natural enemies. Collections of natural enemies are made in various foreign countries where the pest exists and from which the pest is believed to have originated. Natural enemies are collected and sent to quarantine laboratories for examination and in some cases rearing. Once quarantine requirements have been met, the natural enemies are sent to scientists who seek to establish the species in nature at one or more sites. After the species is established, evaluations are made to determine the impact it has on the target pest; and if results are favorable, it is redistributed to all the parts of the state or country where the pest occurs. This process may be rapid or may take many years, depending on how quickly explorers locate effective natural enemies and how large the infested area is to which the natural enemies must be distributed. For example, the USDA successfully controlled the alfalfa weevil in much of the United States. This project took nearly 20 years and covered the majority of states in the country (Day, 1981). The savings to American farmers, however, have been very large. Over $8,000,000 of benefits are gained each year on an original investment of only $1,000,000. Currently, another large project, this one against Russian wheat aphid, is underway. The USDA through its cooperating research (ARS) and service branches (APHIS) intends to greatly shorten the time for this project by conducting it on a larger scale from the beginning. Currently, biological control targets are selected with no specific consideration for the needs of organic farmers. This is one point on which organic producer associations must focus if the biological control importation method is to be put to work for their interests.

How organic farmers can put classical biological control to work for them

Because importation of new natural enemies is an activity that requires the skill of entomological specialists and must be conducted within the framework of quarantine laws, organic producers must look to universities and their state and federal agricultural agencies for leadership in classical biological control projects. There are several key steps in this process on which associations of organic farmers should focus their attention. The first of these is the selection of which pests are chosen as targets for biological control projects.

Currently, biological control introductions are done either by federal entomologists in the USDA or by state entomologists in state land grant universities or state departments of agriculture. At the federal level, the ARS (Agricultural Research Service) has historically been responsible for classical biological control work. More recently, APHIS (Animal and Plant Health Inspection Service) has also taken a role in such work. State level programs have been of two kinds. In a few states, mainly California, Florida, Hawaii, and Texas, programs have been conceived and carried out using state resources from target identification through foreign exploration to importation, colonization, and evaluation. In most states, however, state activities have been limited to that of being cooperators with federally conceived projects for which the states act as recipients of natural enemies obtained by federal entomologists.

Because organic producers often have limited acreage, they are likely to grow high-value fruit, berry, vegetable, and flower crops, rather than major national-level crops like cotton, corn, soybeans, etc. Federal selection of pests as targets for biological control projects, however, is largely driven by the economic importance to the nation as a whole of the crops which the pests attack. Consequently, there are currently few federally initiated biological control projects focused on pests of the crops that organic producers typically grow. Farmers in

states like California and Florida which run their own biological control programs do better in this regard because projects can relate more directly to crops of significance in the state ragardless of their national-level significance.

Systematic reviews of the biological control potential of the pests affecting minor crops is needed to identify what pests on which crops have the best potential to be controlled through biological control importations. Van Driesche and Carey (1987) present results of this type of review for crops of importance in Massachusetts, including vegetables and small fruits--two crops often grown by organic producers in the northeast U.S. Maryland (Barbosa, personal communication) has recently initiated a similar review. National-level reviews of this type are being planned in Mexico and Kenya. Significantly, no such review exists at the national level for the U.S. Creation of such a review is one major goal which organic producer associations interested in enhancing the utilization of classical biological control should pursue.

Other actions needed to expand the use of classical biological control in the U.S. are (1) the development of a national policy on biological control, (2) establishment in each state of a Biological Control Coordinator position within the land grant university system, and (3) strengthening of extension services' abilities to provide useable information about biological control to growers.

A national-level biological control policy needs to be developed so that the activities of the four groups involved in biological control, i.e., USDA-ARS, USDA-APHIS, the state land grant universities, and the state departments of agriculture, can be coordinated. Matters as to which pest problems should receive priority for funding, how to fund and integrate activities of all parties working in a given project, and policies concerning importation strategies and safety issues all need attention. Only a few tentative steps, however, have so far been taken toward creating such a unified national biological control policy. Organic producers wishing to express themselves on this issue can contact Dr. Soper (USDA-ARS), Dr. Meyerdirk (USDA-APHIS), or Dr. Cate (state land grant university representative), whose addresses are given below.

Within a state, the pace of implementation of classical biological control projects can be increased greatly through the existence of a person charged with promoting all aspects of such an effort, i.e., a Biological Control Coordinator. The ways in which having a Biological Control Coordinator helps promote biological control are numerous, including identification of good projects that fit local needs and finding ways to initiate such projects, developing sources of funding in the state for biological control research, and leading efforts to provide extension agents with training on biological control (Van Driesche, 1989a). Fewer than ten of the fifty states currently have at least one full-time biological control specialist in their land grant universities. Organic grower associations can best express their concerns on this subject by contacting deans of schools of agriculture in their states.

Extension agents link growers to research developments and play a vital role in biological control projects. Several important issues need attention if agents are to be provided with the knowledge and specific training materials they need to serve as sources of biological control information for growers (Van Driesche, 1989b). Interest in developing the tools to meet these needs is growing and would be enhanced by the establishment of state-level Biological Control Coordinator positions.

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Trees and Sustainable Agriculture

Peter R. Schaefer

Abstract. *In the United States, trees constitute an element in agriculture whose importance has been inadequately appreciated. In actuality, they are highly important in several ways. From the time of the earliest settlements, they have served as a source of building materials and energy. They protect the soil against erosion by wind and water. When used as windbreaks adjacent to crop fields, they protect crops against the damaging effects of wind on crop yields. As windbreaks for livestock, they increase feed conversion efficiency, improve weight gains, and increase the survival rate of newborns. They provide habitat for wildlife and contribute aesthetically to the appearance of the countryside. They protect water resources. Trees need to have the story of their great benefits more widely and emphatically told.*

Key words: building materials, energy source, soil erosion protection, crop yield increase, livestock protection, wildlife habitat, aesthetic landscape enhancement

Introduction

The importance of trees in sustaining agriculture in the United States is almost completely ignored in the sustainable agriculture literature. In contrast, trees are considered a significant component of sustainable systems in less developed and resource depleted nations throughout the world. Does the apparent lack of attention in the United States indicate that trees are not considered important in sustainable agricultural systems, or is their role so obvious that there is no need to dwell on it in the literature?

Both of these views have some truth. I will try to shed some light on these ideas through a discussion of the relationship of trees and agriculture and the value of trees to agricultural systems, followed by a consideration of what I think to be some of the underlying reasons why trees have been largely ignored in discussions of sustainable agriculture in the United States.

Trees have almost always played a very prominent role in the American agricultural experience. When this country was first settled, almost every square foot of tillable land had to be wrested from the extensive forests that covered the eastern half of the nation. Although trees were a great nuisance, they also were valued because they provided abundant building materials and a ready source of energy. Therefore, as settlements moved west and farmers began cultivating the treeless prairies, they made great efforts to establish trees.

Yet even in the plains, many people consider trees an obstacle and a nuisance to agricultural production. They stay where you put them, and they will stay there a long time if properly cared for. But the very fact that they are an obstacle, and a fairly permanent one at that, is what makes them such a valuable component of resource conservation systems. Even so, trees have generally not fared well in the face of agricultural production.

Agricultural development and resource conservation

The deforestation that often accompanies agricultural expansion can have disastrous results on soils. As Kirschenmann (1988) has written in this journal: "One of the lessons of history is the fact that whenever a civilization mines its soil to enjoy short-term prosperity, that civilization suffers long-term famine and poverty." This view was expanded by Sampson (1989), who wrote: "There is no irrevocable conflict between a strong economy and a healthy environment. In fact, the two must be considered together, particularly if any significant time frame is involved. No society can get wealthy and stay wealthy by ruining the natural resource endowment upon which all wealth is based." He concludes that, "Soil conservation and water quality protection are not the optional activities of an affluent society, they are the essential fabric of a sustainable society."

Throughout much of the world, the critical importance of protecting soil and the conservation value of trees have not been taken into account until it was too late. Heavy population pressures, coupled with poor land management practices, have resulted in massive natural resource degradation in many nations. Nations such as China and Nepal face tremendous struggles to rebuild their

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natural resource base, with trees playing a pivotal role in these efforts (MOF, 1985; Brown, 1982, 1985). Where building materials and fuel are in critical supply, trees are incorporated into agricultural production not only as a means of resource conservation, but for the wood that they produce. In many areas of the world, trees are cultivated in association with food crops to maximize the production of both food and fiber from every parcel of arable land (MOF, 1985; El-Lakany, 1986; Jackson, 1987).

Trees are an essential component of a sustainable society. In developing a sustainable agriculture in the United States, the role of trees in such systems should be given due consideration. Because we are still blessed with a magnificent natural resource base, we lag behind much of the world in establishing sustainable agricultural systems. The survival of our society has not yet depended on establishing sustainable agricultural systems. This is a testament not only to the wealth of natural resources that we are blessed with, but also to the resilience of the ecosystems across much of our country. In our attempts to gain a better life through resource depletion and degradation, we have behaved no differently from most civilizations past and present. Fields have been impoverished, forests have been devastated, and water resources squandered. Our resource base remains sound primarily because these areas were given time to recover, a luxury that nations with higher population densities do not have.

The value of trees to a sustainable agriculture

It now appears that we may be approaching the end of an era and that we must now prepare for agriculture after the oil age (Sampson, 1989). Widespread public concern over the amount and quality of our water resources, the nearly ubiquitous use of farm chemicals, and a growing belief that our current system of agriculture cannot support itself without tremendous infusions of tax dollars are fueling the drive to establish sustainable agricultural systems. I will illustrate the potential value of trees in such systems by showing how they can fulfill several principles of the general concept of sustainable agriculture, as discussed by Lockeretz (1988), Erb (1989), and the American Society of Agronomy (AJAA, 1988). Particularly relevant are the following:

- Protect the soil so that erosion, contamination from sediments, and losses of water and nutrients are reduced and overall soil quality is maintained or improved;
- Cultivate a diversity of crop species to improve the biological and economical stability of agriculture;
- Improve farm profitability without sacrificing production;
- Enhance the quality of life both on the farm and for society as a whole.

Protection of soil resources

Trees have been planted in sub-humid and semi-arid regions throughout the world to reduce soil erosion and to halt or slow the process of desertification. They serve the same function in more moderate climates, but the most spectacular and massive efforts at establishing trees for this purpose have occurred where conditions have been extreme. A striking example of resource recovery occurred in the United States during and immediately following the dust bowl years in the 1930's. Two hundred twenty-three million trees established in 18,599 miles of field windbreaks from 1935 to 1942 dramatically changed the landscape of the region and helped to make the land productive again (Bagley, 1985). Present efforts in China and South Korea, where several million hectares of degraded lands have been planted to trees, are also noteworthy (MOF, 1985; Brown, 1985). It is unfortunate that such efforts are generally undertaken only after severe damage has occurred. Although trees have served to restore damaged lands, they may serve equally well in preventing such damage in the first place if they are included as an integral part of agricultural systems.

Wind erosion may be controlled by adhering to several basic principles (Lyles, 1988; Tibke, 1988):

- Maintain a vegetative or residue cover on the field at all times;
- Maintain non-erodible clods or a gregates on the soil surface;
- Reduce field widths along the rection of the prevailing winds;
- Roughen the surface of the land

Of course, trees are not the o means of fulfilling these principals protect soil against wind erosion. In fa both authors stress a combination practices, but this does not lessen importance of trees. It is generally knowledged that wind barriers cont wind erosion completely for a leew distance of 10 times the height. Tr provide the tallest wind barrier tha feasible to use in most areas and, the fore, allow the greatest field width tween barriers.

Other vegetative barriers are used control wind erosion. Perennial (Bl and Aase, 1988) and annual (Bilbro a Fryrear, 1988) herbaceous barriers h been used successfully in the semi-a plains of the United States. Advanta of herbaceous windbreaks rather t trees or shrubs are that they are expensive and faster to establish and t large fields are typical in the semi-a plains (Black and Aase, 1988). Peren herbaceous barriers are also very eff tive in trapping and spreading sn across the field.

However, if we are concerned w assuring that resource conservation c tinue over the long term, trees have c tain advantages over herbace barriers. Most important, they usu are very long lived when properly ca for and are not easily removed once t have matured. In addition, trees continue to provide protection even d ing a drought severe enough to m herbaceous barriers fail. Tree wi breaks also take less land out of p duction than herbaceous barriers. Bl and Aase (1988) determined that tw row tall wheatgrass barriers removed percent to 12 percent of the land fr production. In comparison, two-r tree barriers 40 feet tall would rem only 7 percent to 8 percent.

Trees may not be the best solution wind erosion control in all situati Furthermore, some areas are not sub to significant wind erosion. Howe control of wind erosion is only one in which trees are valuable to a sust

able agriculture.

Crop diversity

Trees can increase crop diversity on the farm in at least two ways. First, the trees themselves may be grown as a crop. Second, the shelter provided by trees allows the cultivation of crops that otherwise would not be possible. This latter point is especially true in areas subject to high winds and other climatic rigors, such as the Great Plains.

Small timber holdings are typical of farms in moist regions of the country where forests occur naturally. Reestablishing woodlots on lands poorly suited for the production of crops like corn, soybeans, or wheat would provide an additional long-term crop for the farmer. The 1985 Farm Bill provided a means for landowners to establish trees on such sites through the Conservation Reserve Program. Many millions of trees have been planted on land once farmed in areas where the timber industry is active, especially the southeastern United States.

Intercropping trees with more typical agricultural crops is another way for trees to increase crop diversity. Intercropping is a common component of agriculture throughout most of the developing world, especially in countries faced with significant population pressures and natural resource depletion, such as China. The practice is not completely unknown in the United States, where nut-bearing trees or high-value hardwoods, such as black walnut, are occasionally grown with agricultural food or forage crops (Jackson, 1987). Studies in Illinois (Campbell and Lottes, 1989) and Missouri (Thurman et al., 1989) suggest that intercropping can be more profitable than traditional agriculture on marginally productive land or where erosion control is necessary. The culture of coniferous species on pasture or range land is found primarily in the southeastern and northwestern United States (Sharrow et al., 1989; Lewis et al., 1989).

The production of vegetable or fruit crops is another means to diversify a farm. These crops typically are very sensitive to wind, and at best they are difficult to cultivate in sub-humid and semi-arid regions of the country. Trees have been used extensively to protect vegetable and fruit crops from harmful weather.

In surveying the world literature, Baldwin (1988) and Norton (1988) found overwhelming evidence for the positive benefits of shelter on vegetable and fruit crops. Crop quality is often more important than quantity for fruits and vegetables. Quality is improved by protecting crops from the wind, which prevents sandblasting, blossom destruction, bruising of fruit and leaves, discoloration, and premature fruit drop (Piggot, 1980). Economically, wind protection is easily justified. Production of fruits and vegetables increased from 5 to 50 percent as a result of protection by windbreaks (Baldwin, 1988; Norton, 1988) (Table 1).

Improving profitability and production

There are several ways that trees may enhance a farm's profitability and production. These include less reliance on off-farm inputs, increased crop production and quality, increased livestock gains on less feed, and a greater variety of saleable products.

Reducing off-farm inputs. A reduction in off-farm inputs is often mentioned in discussions of sustainable agriculture (Lockeretz, 1988). Tree windbreaks and woodlots are a way of addressing this goal. Trees provide fenceposts and firewood and, if managed properly, may also provide lumber or veneer grade timber. In one example from New Zealand, a single row of 22-year-old radiata pine was valued at $20,000 per kilometer (Sturrock, 1988). Admittedly, this is an extreme example of the potential for profit from tree windbreaks. It shows that, with the right combination of species, climate, and markets, substantial monetary gains are possible. In the United States, high-value hardwoods such as black walnut, black cherry, and red or white oak have considerable market potential. However, growing sawlog-size trees is no get-rich-quick scheme even under very favorable climatic and soil conditions. It is doubtful that marketable trees of the species mentioned could be produced in less than 40 or 50 years. As an alternative, many tree species will produce rough lumber for on-farm uses in less than 40 years.

Trees are also an important source of food for both humans and animals worldwide. Depending on location, a variety of fruits and nuts can be grown on the farm rather than purchased. In addition, several species provide nutritious and often abundant animal feed (Smith, 1950; Bagley, 1981, 1988).

Aside from producing a product themselves, trees allow the reliable production of fruits and vegetables in areas where this would otherwise not be feasible. Reducing the need for off-farm

Table 1. Benefits of protection from wind for selected vegetable, fruit and specialty crops[a]

Crop	Yield increase (%)	Other effects
Sugar beet	6–25	8%–20% increase in sugar content. Improved press-juice purity. 15% quality bonus when sold.
Tobacco		Reduced nicotine content.
Strawberries	0–56	30% increase in prime quality yield.
Soya beans	8–26	
Snap beans	37–44	
Dry beans	10–21	
Tomatoes	16	60% higher yield at early harvest. 30% increase in marketable product.
Potatoes	6–19	
Asparagus		Fewer soil-filled (unmarketable) shoots.
Lettuce		Reduced tip burn.
Fruit trees		Average loss of 35% of product without protection.
Plum	32–37	10% increase in export quality fruit.
Valencia orange		25%–77% increase in export quality fruit.

[a]Based on data summarized by Baldwin (1988) and Norton (1988).

food purchases is certainly one means of improving financial stability.

Off-farm energy inputs can be reduced in many ways, such as by changing cropping and tillage practices and insulating buildings. Windbreaks are also a very effective means of reducing the costs of heating homes and outbuildings. Savings of up to 25 percent are possible in the north central United States (DeWalle and Heisler, 1988). In less windy climates, such as the northeastern United States, home heating costs may be reduced as much as 15 percent. Properly designed windbreaks will also reduce or eliminate the need for removing snow from work areas and feedlots, which can save as much as several hundred dollars per year (Wiles, 1982).

Increased crop production. Many studies throughout the world have demonstrated significant gains in the quantity and quality of crops protected by windbreaks (Table 2). Trees compete for resources with directly adjacent crop rows, but any yield reduction in these rows is more than offset by gains in the rows that are two or more tree heights from the windbreak (Bates, 1944; Read, 1964). Obviously, trees take land out of agricultural production. But again, increased crop yields more than make up for this loss. Recent studies in Nebraska indicate that windbreaks result in a $19 million increase in grain production each year (based on 1983 prices, production averages, and acreages; increase of 4,172,563 bushels of corn, 451,045 bushels of soybeans, and 973,845 bushels of winter wheat) (Wardle and Schmidt, 1985).

In summarizing the results of research in 14 countries, Kort (1988) suggested that winter wheat, barley, rye, millet, alfalfa, hay, and to a lesser extent spring wheat, oats, and corn exhibit positive responses to windbreak protection, ranging from 6 percent to 99 percent (Table 2). Based on only one or two studies each, nine additional crops showed increased production, ranging from 10 percent to 100 percent (Table 2). Only three of the 97 studies reported by Kort (1988) revealed a negative response to shelter.

Many variables are involved in crop responses to shelter, so that the value of windbreaks will vary from year to year, depending on conditions. Over the long run, windbreaks will produce higher average yields for most field and forage crops, while reducing risks associated with weather extremes in any one year.

Increased livestock production. Livestock windbreaks provide several kinds of significant benefits both in feedlots and on pasture and range lands. First, the quantity of forage is improved on pastures protected by windbreaks (Lynch and Marshall, 1969). More importantly, windbreaks increase feed conversion efficiency, weight gains, and survival of newborns, and improve animal health, all of which in turn result in greater profits (Dronen, 1988). Also, protecting livestock with windbreaks offers an additional reduction in off-farm inputs because substantially less feed is needed during the winter (Morrison et al., 1979; Aldrich, 1977; Dronen, 1988).

In Tasmania, Australia, it has been estimated that it is economically justifiable to dedicate from 1 to 5 percent of every farm to shelter plantings (Bottomly and Parker, 1974). Providing protection from climatic stress during winter and early spring can be extremely important in temperate climates (Aldrich, 1977; Holmes and Sykes, 1984). The Nebraska Forest Service (Wardle and Schmidt, 1985) estimates that windbreaks save $1.5 million annually f cow-calf operations in that state a save an additional $1.5 million for fe lots (based on 1983 prices; increase 17,550 calves and $10 per head f 159,000 protected head of cattle for t months December-March).

Increasing the production of saleal products and wood. Beyond providi posts, poles, rough lumber, firewo fruits, and nuts for on-farm use, and lowing more reliable on-farm producti of vegetables, trees can provide ad tional sources of income if these pr ucts are produced in sufficient quanti Probably the most important cause the increasing use of trees in agricultu systems worldwide is the widespre shortage of wood. This shortage direc affects over one billion people for wh enough wood to cook meals and h homes is becoming scarce or unavaila (Postel, 1988).

In contrast to tropical forest regio (where most developing countries are cated), the forest area in temperate gions is remaining fairly stable and some countries is actually increasi (Postel, 1988). Unfortunately, this is n true of the forest area in the Unit States. During the last 20 years, the f est area in the U.S. has declined by percent to a post-settlement low of 2 million acres, as a result of conversi

Table 2. Yield increases for 18 crops due to windbreak Protection[a]

Crop	Number of studies	Number of field years	Yield increase (%
Alfalfa	3	3	99
Millet	6	18	44
Barley	8	30	25
Winter wheat	16	131	23
Hay (mixed grasses and legumes)	6	14	20
Rye	9	39	19
Corn	6	209	12
Spring wheat	21	190	8
Oats	12	48	6
Brome grass	1	—	100
Wheatgrass	1	5	36
Corn silage	1	—	30
Clover	2	—	25
Rice	1	—	24
Sunflower	1	6	16
Cereals	1	—	15
Mustard	1	2	13
Flax	1	2	10

[a]Based on data summarized by Kort (1988).
[b]Weighted mean = % increase or decrease multiplied by the number of field years for each study. Tot were summed across studies and divided by the total number of field years.

to crop land and encroachment by urban and industrial development. Although improved technologies and management help to offset the effects of a declining forest area, the United States consumes more wood than it produces and, in fact, has done so since about 1945 (Hall, 1983). Imported wood presently supplies about 20 percent of U.S. demand. Continued erosion of the forest land base will not help to reduce our reliance on imported wood.

The increasing world demand for wood, coupled with a decreasing forest land base (WRI, 1986; Postel, 1988), suggests the need to produce these products on sites other than natural forests or plantations. Including trees as an integral part of agricultural systems will provide the landowner with additional income and the many benefits of tree shelter and will help to alleviate the shortage of wood worldwide.

Many nations willingly convert some productive capacity from food and forage crops to tree crops and wood production. Agroforestry, the intensive use of trees in agricultural systems, promotes wood production, rehabilitation and conservation of soils, and protection of crops and livestock. Besides the value of the wood produced, the trees often provide other direct benefits. For example, leaves from the lower portions of the trees are often used for forage (Smith, 1950; Brown, 1982; Bagley, 1988), while many trees also produce fruits or nuts suitable for animal or human consumption.

Agroforestry is practiced not only in developing or resource-depleted nations, but in resource-rich nations such as New Zealand, Australia, and the United States. Quite often such systems include trees on pasture or range lands (Reid and Wilson, 1986; Sharrow et al., 1989; Lewis et al., 1989). New Zealand has done the most to develop the idea of timber production in conjunction with windbreaks (Sturrock, 1988), an example of which was presented earlier.

Enhancing the quality of life

If shown side-by-side pictures of two farms, one surrounded by trees and one surrounded by open fields, few people would select the latter as the more desirable place to live. Trees break up the monotony of crop land, soften the microclimate around farmsteads, attract wildlife, and reduce dust and noise levels that are often caused by agricultural activities. In addition, the many benefits of trees and windbreaks mentioned in previous sections also relate directly to the quality of life on the farm.

Incorporating more trees in agricultural systems in the United States and throughout the world can also improve the quality of life for those of us who do not live on a farm. Trees remove pollutants from the air and protect watersheds, and so can be considered a world cleansing machine that is constantly working to keep this planet habitable. The rivers of China and the deforested areas of the tropics provide clear evidence of the importance of trees in protecting our water resources. The role of trees and all green plants in regulating the earth's climate has received much attention in recent years, primarily because of concern over massive deforestation in the tropics and global warming. Whether the drought of 1988 in the United States and weather aberrations in other areas of the world were a result of global warming is debatable. However, most predictions indicate that we can expect such a warming, regardless of whether we are already experiencing it. Trees play a very important role in moderating this warming trend by removing carbon dioxide from the air to manufacture carbohydrates. Efforts are under way to plant more trees to combat global warming (Sampson, 1988), but very many trees would have to be planted to have a significant impact. The development of sustainable systems of agriculture that include trees would assist in this effort.

A failure to communicate

The use of trees as the basis for a sustainable agriculture has been slow to take hold in the United States. There is a sound body of research to support the incorporation of trees into agricultural systems. Why, then, is there so little mention of trees in connection with sustainable agriculture?

Perhaps the love/hate relationship that agriculture has had with trees since this country was settled is at the root of it. Trees are nice, but they get in the way. To this day, trees on agricultural lands are tolerated, when at all, as conservation measures and are not generally recognized as income producers by much of the agricultural community. Why is this?

Sturrock (1988) identified ten reasons for the slow progress made in the acceptance of trees by the agricultural community, five of which seem especially relevant to the United States:

- Older plantings required too much land relative to the amount of protection provided;
- Economic pressures which act to physically restrict the area available for trees;
- A frequent lack of quantitative data on shelter effects on crops and livestock on a *local level*;
- Most windbreaks have been poorly managed and, therefore, are in poor condition. The sight of deteriorating windbreaks does not inspire farmers or their advisors to pursue windbreak plantings;
- Most farmers have small appreciation for the intrinsic value of the trees themselves.

All of the above act as disincentives to the use of trees in agricultural settings. Especially insidious are past design problems (e.g., 10-20 row field windbreaks) and the poor condition that many windbreaks are in today. The days of 10- or 20-row field windbreaks for crop and soil protection are long past. However, their specter still haunts landowners today, having firmly implanted the idea that field windbreaks take too much land out of crop production to justify their existence. The one- to five-row field windbreaks generally promoted today (SCS, 1974) occupy very little space relative to the benefits they provide.

Several studies have indicated that the majority of windbreaks in the Great Plains are in a state of decline and in need of renovation or replacement (USDA, 1977; Schaefer et al., 1987; Fewin and Helwig, 1988, citing unpublished data of Fewin and Slosser, 1979). It is estimated that 61 percent of the

windbreaks in South Dakota are in need of renovation to return them to an effective condition (Schaefer et al., 1987). Many reasons have been given for the decline of windbreaks in the plains, including poor species selection, disease and insect problems, the effects of drought, damage from herbicides, and poor management. Schaefer et al. (1987) and others (Bagley, 1988; Sturrock, 1988) have suggested that poor management lies at the root of windbreak deterioration. In South Dakota, 83 percent of the windbreaks were estimated to be infested with grass and other herbaceous vegetation. Windbreaks in good condition were generally weed free, while those in poor condition were not (Schaefer et al., 1987). Windbreaks 40 or more years old that had received good care were generally still in good shape.

As is true of most endeavors, the return derived from windbreaks largely depends on the effort put into them. The proper establishment and care of windbreaks requires a commitment of time and energy. Well-managed windbreaks work well; poorly managed windbreaks do not. Instilling landowners with the desire to aggressively manage their trees is an important key to establishing effective, long-term windbreaks. It is also the area with which windbreak advocates have had a great deal of difficulty. Most farmers don't allow weeds to overrun their crops, so why do they ignore weeds in their trees? Both Bagley (1988) and Sturrock (1988) suggested that farmers generally fail to consider that their trees have a value in and of themselves, in addition to the benefits provided to the rest of the farming operation. Because of this, there is little incentive to care for the trees. Trees and windbreaks must be accepted as an integral part of the farm-cropping system before they will generally be afforded necessary care. Apparently such acceptance is still far from manifesting itself in the agricultural community. I have already proposed many reasons for this, but there is at least one more aspect of this problem that I would like to touch on.

Consider the organizations and agencies that promote tree planting on agricultural lands: the Soil Conservation Service; local conservation districts; state forestry divisions; the U.S. Forest Service; the American Forestry Association; the American Forest Council through the American Tree Farm System; and the National Arbor Day Foundation. This list is definitely not all-inclusive, but it does serve to make a simple point. Except for the Soil Conservation Service, none of the above are closely allied with the agricultural production community. All of the above are concerned with trees or conservation of natural resources. Conservation to many people still means added costs with little promise of actually generating additional income. It is something one does because it is the "right thing to do" or because there are regulations that require it. The long-term benefits of conservation are much harder to sell than something that will generate income in the not-too-distant future. Throughout the Great Plains, tree seedlings are marketed as "conservation trees." One might question the wisdom of this. Trees are income producers as well as a good conservation measure. They should be promoted as such.

Regardless of where to place the blame, tree planting on agricultural lands has suffered through a failure to effectively communicate the value of trees to the agricultural community of researchers, federal and state agencies, private industry, and landowners. Forestry and conservation interests are outsiders, and the impact of their message is lessened by this fact. Real progress can only be made with support from the inside as well. An agronomist, beef specialist, or agricultural economist telling a farmer that production could be stabilized or increased through the establishment of tree windbreaks would be more effective than a "conservationist" with the same message. Before farmers, ranchers, and other rural landowners can be expected to more fully embrace tree planting, the help of influential individuals and organizations directly involved in agricultural production will have to be enlisted. This could be a formidable task, since even those presently involved in promoting a sustainable agriculture in this country have largely overlooked the value of trees.

Trees for a sustainable culture

"One telling measure of humanity progress toward sustainability is the e tent of efforts to plant trees" (Brow 1985). Clearly, trees can have a larg part to play than just their tradition forestry role, or even their role in su tainable agriculture. With few exce tions, trees are a requirement for *sustainable culture*. This role was e pounded in detail by Smith (1950) in h book, *Tree Crops, A Permanent Agr culture*. Greater efforts at communica ing the value of trees to agriculture w be needed if planting trees on agricu tural lands on a large scale is going be achieved. Otherwise, we can sit a wait for the next environmental disast to do the communicating for us.

South Dakota Agricultural Experiment Station Pap No. 2470.

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EPA proposes ban of EBDCs

Most uses of the nation's most widely used fungicide chemical, ethylene bisdithiocarbamate (EBDC), will be banned within 18 months, Environmental Protection Agency Administrator William K. Reilly announced on December 4, 1989. EBDCs are a family of chemicals used to fight fungal diseases on about one-third of the fruits and vegetables grown in the United States. Research has shown that they break down from decay or heat into a potent carcinogen, posing risks higher than allowed by the national EPA dietary standards. Use of EBDCs on tomatoes, potatoes, bananas, and 42 other types of produce would be banned. The chemical could continue to be used on 10 crops: grapes, wheat, cranberries, onions, sweet corn, peanuts, almonds, asparagus, sugar beets, and figs.

ATTRA funded for 1990 with Interior Department

ATTRA, the Arkansas-based hotline information service for low-input/sustainable agriculture, has received FY1990 funding through the Fish and Wildlife Service of the Department of the Interior. Funding through the Department of Agriculture was opposed by Congressman Jamie Whitten (D-TN) after the information center was moved from Tennessee to Arkansas. Senator Dale Bumpers (D-AR) then proposed funding through the Interior budget. The hotline (1-800-346-9140) will continue its service of referrals to technical experts in sustainable agriculture. The ATTRA address is P.O. Box 3657, Fayetteville, AR 72702.

The Agricultural Scientific Enterprise: A System in Transition. 1986. Lawrence Busch and William B. Lacy, Editors. Westview Press, Boulder, Colorado. 348 pp. $32.50, paper.

The Hatch Act, which established the State Agricultural Experiment Stations, was signed in 1887. As the editors of this book indicate, its one hundredth anniversary offered an occasion "to stop, pause, reflect, and rethink, to compare the needs of yesteryear with the needs of today, and to consider the appropriateness of [its] goals and objectives...". To do that, as well as to celebrate the anniversary, the editors organized a symposium at the University of Kentucky in 1985 with the support of the Experiment Station Committee on Organization and Policy and the USDA Cooperative State Research Service. This book is the result. Twenty-three chapters address seven different topics: 1) the historical and philosophical context; 2) research priority setting; 3) disciplinary and interdisciplinary research; 4) commodity studies; 5) the experiment stations and science education; 6) the dissemination and impact of experiment station research; and 7) future directions.

The thirty-four authors embody a diverse mix of perspectives and positions. Economists, agricultural economists, sociologists, and rural sociologists are the most heavily represented, followed by several Experiment Station and USDA administrators. Several historians and philosophers are included, as well as a few production scientists and others. This mix, although it somewhat underrepresents the natural sciences, does offer a much wider range of perspectives and topics than is typical in many agricultural anthologies. This is due not only to the wider range of disciplines included - especially philosophy - but also the reflective and critical character of most of the authors.

The resulting book is generally thoughtful and as a whole achieves its objectives, although that judgment depends somewhat upon which groups one considers to be the main audience. Given the sponsorship of the symposium, the "establishment" was clearly one of the audiences. For that audience, the book offers a much more thoughtful and challenging review than is typically found in official pronouncements.

In the Foreword of the book, Orville G. Bentley and John Patrick Jordan concentrate on the problems of the 80's. These include: the overvalued dollar; the farm credit problem; demands for safer food and better nutrition; soil erosion and water pollution; and new demands for more timber and rangeland. Besides addressing these problems, they see a need for focusing research to sustain increased productivity, to reduce surpluses through better marketing, and to increase efforts towards international cooperation. Thus for them, the transition of the book title involves some adjustments and some new initiatives, but little in the way of fundamental change.

Busch and Lacy in their too brief Preface offer a longer-term, broader perspective. They stress how the State Agricultural Experiment Station (SAES) system offered a new model for the world, especially in its early days, in seeking to institutionalize "a utilitarian concept of agricultural science." Over time the system has evolved and has developed new priorities and partnerships, and today is facing significant change and transition. The new - and much more fundamental - challenges that they see involve resource limits and sustainability, the risks of corporate involvement in setting public research agendas, the demands for greater accountability, and the questioning of whether increased production and productivity should continue to be major future research goals. While they briefly summarize the various chapters, there is unfortunately no attempt to assess or evaluate them either here or elsewhere in the volume.

The different parts of the book will have a different appeal to different readers. However, a reading of all of them (something I strongly recommend) will provide much material for reflection, ranging from the discussion of the original Hatch Act's compromises between research and practical advice and between the respective roles of the states and the federal government, to the periodic redefinitions of priorities over time (something resulting both from externally generated changes and from the SAES system's own impact on U.S. agriculture), to today's challenges.

The early chapters are particularly valuable in placing the SAES system in a larger historical, philosophical and socio-political context. Many other chapters also include important historical and socio-political discussions. Next, the basic problems of priority setting are discussed at three levels: those of the individual researchers, state administrators, and federal legislators. There also is a discussion of how a new technology - computers - can affect setting of priorities. The three different ways of organizing research (along disciplinary lines, along interdisciplinary lines, and along commodity lines) are examined through a series of case studies covering soil erosion, integrated pest management, rice, hybrid corn and wheat. The commodity studies are particularly interesting in that they offer comparisons between public and private research approaches (hybrid corn), different regional approaches (rice), and a case study of the history of the Kansas State Experiment Station's research on wheat.

A series of chapters then examine the role of the SAES system in training both Land Grant scientists and foreign agricultural scientists, the degree to which the system has served as a model for the international agricultural re-

search centers, and how agricultural research has influenced U.S. farm structure. The final chapters turn to future directions and challenges, headed by a call for a "new covenant for agricultural academe" by Patrick Madden. The questions of the technology transfer capabilities of the SAES system and the impacts of biotechnology upon it receive detailed treatment, particularly the institutional dimensions. In general, this section poses the dilemma of how to retain public support for the SAES system with fewer farmers and increasing agribusiness influence. In the concluding chapter, Sylvan Witwer's sobering summary of the challenges the various authors see facing the SAES system is combined with his optimism that with a clearly redefined mission, the system will be able to carry its overall positive work into the next century.

Readers of the AJAA are likely to be familiar with many of the themes and issues covered in this book, but the broad historic, philosophic, and sociopolitical overview is unusual. And while no one chapter really does justice to the theme, overall the book provides a good sense of the larger dynamics of agricultural change over the longer term - something that involves complex feedbacks between scientific, technological, and social developments. As alternatives for the future are sought, the experience embodied in the successes, trials, and failures of the SAES system should be carefully considered. This book provides a most valuable way to gain that needed perspective. - - *Kenneth A. Dahlberg, Professor, Department of Political Science, Western Michigan University, Kalamazoo, MI.*

Private Interests, Public Policy, and American Agriculture. 1988. William P. Browne. University Press of Kansas, Lawrence, Kansas. 294 pp. $29.95, cloth; $12.95, paper.

It seems that political scientists, perhaps more than most social scientists, frequently find themselves trying to say more than they know. Maybe that is because politics, by its nature, tends toward duplicity, and the professional observer of this art is anxious to assure the less informed that he hasn't been duped. The problem is, the further he stretches, the more likely he has been.

That goes a little too far in criticism of William P. Browne's substantial effort to describe the role of private interests in the making of agricultural policy in the United States. But it goes too far in the right direction.

In trying to assemble a truly thorough taxonomy of agricultural interests that play out their hands in the making of farm legislation, Browne attempts a real service. And there is no question but that he succeeds in making a contribution. He is inclusive nearly to a fault, delineating the major and minor players, the obscure as well as the prominent. His short history of the rise of the American Agricultural Movement and its internal heaves and throws; his attempt to place the indigenous (and largely Midwestern) agricultural reform movements in perspective, especially their success at building a support base by providing meaningful technical and support services to financially stressed farmers; his largely accurate analysis of how traditional farm organizations responded to the political challenge of these groups during formation of the 1985 Food Security Act; and his description of the important role of conservation issues in forging support for that legislation, all serve to provide a richer analysis of private interests in agricultural policymaking.

But he can't seem to avoid trying to be one of the good old boys. He seems preoccupied with the American Agriculture Movement, the lightening rod for scorn from the agricultural establishment because of its internal problems and its early militant character. And he doesn't seem to recognize that AAM is not the center of the agricultural policy reform movement.

In some cases, his distance from these reform groups is revealed in serious factual error. For example, the three times he mentions my own organization, the Center for Rural Affairs, he is simply dead wrong in his facts. I was astounded to read that after the 1978 tractorcade, "...the Center for Rural Affairs joined to bring other small farm-advocacy groups together in support of AAM-inspired legislation." With all due respect to Mr. Browne (as well as to my friends in the AAM), the record is plain that the Center for Rural Affairs has been roundly criticized by many in agricultural reform groups for not supporting, never mind organizing support for, AAM-inspired legislation or the more recent Harkin-Gephardt version of supply management. Browne may have mistaken the Center for Rural Affairs for some other organization, or he may have simply listened to the erroneous impressions of some good old boy on Capitol Hill, but for the record, his facts are wrong.

Like most of the established agricultural interests with whom he is probably more comfortable, Browne wants too badly to lump the richly diverse groups who have entered the agricultural political arena into some categories, like branded cows. He manages two: Agrarian protest groups, including those he seems to believe are marginally legitimate because they are farmers; and Externalities/Alternatives Organizations (a term he borrows from political scientist Don F. Hadwiger), which includes roughly everyone else who isn't a farmer and who isn't entirely happy with farm policy either. These include such diverse interests as anti-hunger advocates, environmentalists, animal rights activists, and those involved in alternative agriculture. He makes no attempt to differentiate these groups in style, purpose, or organizational character. It's as if he wandered around DuPont Circle for a few days writing down names from building directories.

In this, Browne demonstrates the most common ailment of agricultural political science: the harmony bias. The harmony bias is revealed by those who are chagrined over the fact that agriculture doesn't speak with one voice, who treat political discord within farm organizations as if it were cancerous, and who view those with broader views of what farm policy ought to be about as if they were par-

iahs.

Browne seems to want to fight this bias, but in the end, he gives in to it. He keeps calling grassroots organizers "zealous," describes the demands of the ex/al groups as "speculative," and summarily refers to "the seemingly minor complaints that many groups have with a major reputable industry." In doing so, he creates a distinction between those whose interest is not only private, but vested, and therefore legitimate, and those whose interest is altruistic, social, moral, or otherwise questionable.

This elitist attitude bubbles over into his analysis of the regular farm lobby as well when he chides some of the "legitimate" producer groups who "come and go" in the circle of Washington lobbyists because they "threaten to overload the policy process with more information about producer needs than can be handled effectively." So much for James Madison and the glories of faction.

The harmony bias blinds those smitten with it from recognizing that harmony is as unnatural to politics as a vacuum is to the environment. For a political scientist, the bias is particularly severe because harmony is to political science what equilibrium is to economics -- an unnatural condition that, if persistent, would eliminate the need for the discipline.

One of the most serious gaps that results is Browne's failure to analyze the relationship between private interest groups and policymakers. Here, the book borders on the naive. Everything seems up front and straight. Possibly that is because Browne relies too heavily on the assertions of the players themselves, about themselves, and about each other. When dealing with political practitioners, one mustn't take too much on its face value.

We learn the obvious, for example, that lobbyists "provide interpretations of political conditions for policymakers" but little or nothing of how interest groups pedal their wares in the halls (and corners) of the Capitol, nothing of campaign contributions and political action committees, and nothing of the considerable power of the party leadership and its constituent politics. How a 294-page book analyzing the role of private interest groups in farm politics can mention Tom Foley only once (and that in connection with animal rights activists, and not in connection with the politics of wheat and feed grains!) and fail to mention Jamie Whitten or Kiki de la Garza altogether, is beyond me. Two pages subheaded "Working with Legislators" just doesn't suffice.

Likewise, Browne is too quick to minimize the influence of agribusiness corporations. He's right in concluding that they are frequently interested in other issues than the commodity provisions of the farm bill. But he's not convincing when he concludes that they "can be counted on only to fill a number of primarily food and trade niches within the total array of policy problems."

On the other hand, Browne seems to make a lot of the media blitzes and grassroots organizing tactics used by protest groups locally in congressional districts. It would have been interesting for him to analyze this phenomenon more carefully. He suggests, correctly, that partisan politics played a part in the development of the controversial proposal for mandatory production controls, but says nothing of how the agricultural protest groups dealt or failed to deal with the partisanship problem. That would have made a useful chapter. But we just get no sense of how farm politics is done, even by those Browne thinks don't do it very well.

Apart from these substantive flaws, the book is not very tightly written and sometimes has a hard time getting to the point. It would be unfair to say that's because there is no point, because there is. The point seems to be that, like it or not, the periphery in American agriculture is growing, and with it the diversity of the players in farm politics. In a sense, Browne gives this away in a most revealing way when he includes in a long list of critics of the agricultural establishment not only those who speak on behalf of farm workers, consumers, the environment, and animals, but those who speak as well for family farmers.

In fairness, Browne has tackled an important subject and he has tried to be both comprehensive and fair. The weaknesses of his book may be due to its pioneering effort to understand the changing character of agricultural politics, which has deservedly drawn a wider and more chaotic field of players. -- *Marty Strange, Senior Associate, Center for Rural Affairs, Walthill, NE.*

Effects of Conservation Tillage on Groundwater Quality-Nitrates and Pesticides. 1987. T. J. Logan, J. M. Davidson, J. L. Baker, and M. R. Overcash, Editors. Lewis Publishers, Chelsea, Michigan. 292 pp. $39.95, cloth.

This book contains the papers from a workshop held in 1986 to assess the water quality impacts of conservation tillage. Although the book contains several good review articles, it is probably mistitled since much of the emphasis is on surface water rather than ground water. The authors probably exhausted all the existing literature on the effects of conservation tillage on ground water quality. The paucity of actual ground water quality and chemical leaching data reviewed here indicates that very little work has been done and that it may be years before a definitive review of the subject can be assembled.

As a whole, the book suffers from an unfortunate split personality. At times I thought I was reading a book about nonpoint pollution of the Great Lakes while at other times I thought I was reading a book about soil and water dynamics associated with conservation tillage. The editors explained in the introduction that the workshop was designed to focus on the Great Lakes, but the general thrust of the book is not well served by the Great Lakes chapters. Perhaps if these chapters were actually case studies related to ground water quality, they would have fit better.

One of the major questions raised by nearly every chapter is the question of preferential flow in conservation tillage systems, especially no-till. Flow

through root channels and macrofauna burrows is a major difference between tilled and untilled systems. Every paper that addressed soil chemical or physical properties or hydrologic changes stressed the importance of preferential flow, yet none of the authors outlined the experiments necessary to understand this phenomenon. This would seem like a reasonable approach when very little is known about a pivotal process affecting chemical leaching to ground water.

Despite the shortcomings of this book, several of the chapters provide excellent reviews of soil and water principles related to conservation tillage. In particular, Chapter 2, on pest management for conservation tillage systems, and Chapters 7 and 8, on soil chemical and biological properties, were very readable, well-organized, and informative. Chapter 7 makes a particularly good point about the perceptions of the producer concerning increased need for chemicals in conservation tillage systems. The authors, W. A. Dick and T. C. Daniel, state that "What is needed is a reversal of the perception that the increased biological activity associated with CT [conservation tillage] is a negative factor that leads to increased fertilizer immobilization or loss, increased insect, and increased disease problems which require greater inputs of fertilizer and pesticides." In fact, one of the best overall features of the book is the review of literature, which demonstrates that in most cases, CT will not lead to increased chemical use. Chapter 11, on processes influencing pesticide loss with water under conservation tillage, was well-written and informative and included the most information on chemical leaching from CT systems. This chapter also contained a good (but brief) overview of modeling pesticide loss by water.

Like most books of this sort, this one will appeal more to researchers and graduate students than to actual farmers or producers. A number of chapters contain useful practical information, particularly Chapters 14 and 15 on nitrogen management and manure management, respectively. In Chapter 15, Walter et al. hit on a critical concept in calling for "a system approach...to optimize the use and protection of all resources together, not one at a time." Chapters 13, 14, and 15 might be useful for extension or Soil Conservation Service personnel advising farmers.

The reader searching for in-depth information on conservation tillage effects on ground water quality will not find it here. It does present a wealth of useful information on soil chemical, physical, and biological changes associated with conservation tillage. This is enough to recommend the book for the researcher, but one should not expect the content to match the title. -- *Richard Lowrance, Ecologist, USDA-ARS, Southeast Watershed Research Laboratory, Tifton, GA.*

Rational Pesticide Use. 1987. K. J. Brent and R. K. Atkin, Editors. Cambridge University Press, New Rochelle, New York. 348 pp. $49.50, hardcover.

This book is a compilation of 24 papers presented at the Ninth Long Ashton Symposium sponsored by the Long Ashton Research Station of the University of Bristol. The theme of the book, as expressed by the editors in their foreword, is to evaluate "to what extent can we make pesticide applications safer, more effective and precise, and more economic than they are today?" The papers are grouped into four sections: environmental issues, application technology, pesticide resistance, and forecasting of pest outbreaks. The various chapters retain, intentionally on the part of the editors, much of their "oral" flavor, with personal, idiosyncratic styles and focus of coverage. The editors' hope in doing so was that "the whole gives a balanced and interesting picture of the whole topic of the rational use of pesticides as seen in the mid-1980s."

Unfortunately, in my opinion, this goal was not achieved. Although the individual chapters present much interesting and useful information, they fail to build a logical, clear picture of any of the four subjects addressed. Specifically, the book suffers at two levels. First, the perspective brought by many authors to their chapters is provincial rather than comprehensive, with heavy emphasis on current circumstances in the U.K., or for some, in western Europe. Noticeably lacking is information from North America and Japan. While information from some Asian countries is included in some chapters (e.g., China in Chap. 21 and Papua New Guinea in Chap. 19), even these fail to review their subjects comprehensively on a world basis. Dempster, for example, in the introduction to Chap. 2 ("Effects of Pesticides on Wildlife and Priorities in Future Studies") plainly states that his remarks are "based primarily on experience in Britain." With such a narrow focus, the chapter naturally fails to give the reader the in-depth review of the topic suggested by the title. For example, no mention is made of pesticide effects on bats, nor of pesticide-caused fish kills or contamination of fish by pesticide residues, nor of the effects that anticoagulent rodenticides are believed to be having (in Britain!) on owls. This narrow focus, plus the shortness of most chapters (average of 14 pages) reduces many chapters to cursory treatments at best.

Unfortunately, the book also suffers from another all too common defect: It has no real structure. Since chapters are little more than oral presentations that have been "fleshed out" a bit and then categorized into four broad themes, it is no surprise that they fail to work together to build a rational view of the subject, chapter by chapter, as would be the goal in a single-author book. Instead, chapters frequently overlap, addressing a given topic from several slightly different perspectives or with different groups of organisms. Also, since there is no overall outline around which the book's four themes are addressed, no provisions seem to have been taken to prevent gaps in coverage.

While overlap and failure to build a comprehensive perspective are the most important defects in this type of compilation, outright conflicts between chapters are also a problem sometimes. An example is Chap. 14, which advances the concept that threshold lev-

els of weeds do not affect crop yield (p. 187), and Chap. 22, in which this concept is refuted (p. 302).

Nevertheless, in spite of the book's failings, some chapters were particularly worthwhile. Of special value were Chap. 14 by Gressel on management of herbicide resistance, and Chap. 18 by Fry on disease forecasting. The chapter by Gressel ("Strategies for Prevention of Herbicide Resistance in Weeds," pp. 183-196) was one of the more stimulating, outlining some of the genetics behind the development of herbicide resistance in weeds and discussing weed control strategies in a manner parallel to insect control strategies. Particularly interesting is the notion that thresholds of weed densities exist below which no crop losses occur. The movement Gressel advocates away from 100 percent weed control clearly is a key conceptual advance that opens the door to true weed IPM analagous to insect IPM, with thresholds, scouting, and chemical applications in response to demonstrated need instead of pre-programmed schedules. Another exciting notion developed by Gressel is that there is a time-specificity to weed problems, so that crops are vulnerable to weed-induced crop losses only for specific periods in their growth. The connection of these management concepts to the management of resistance was also well developed by Gressel, and it was rather disappointing to find Cussans et al. refuting the threshold concept in Chap. 22. If this book had had a single author, this conflict would have been addressed and resolved. Under the existing format, readers who are not weed specialists are simply left with two conflicting points of view, unresolved as to their relative merits. The chapter by Gressel also usefully points out the role of industrial sites (like railroad beds), where high levels of herbicides are applied repeatedly, as breeding grounds of triazine herbicide resistance in weeds. This has practical importance for states that may wish to regulate such practices to retard development of resistant weed populations.

The chapter by Fry ("Advances in Disease Forecasting," pp. 239-252) was also very readable and balanced. It provides a clear discussion of the various types of forecasts, the history of their development, and numerous literature citations of particular forecasting schemes.

The book as a whole, however, stands as a caution against overzealous publishing of proceedings. A good conference paper is not necessarily a good book chapter, and many good papers taken together are frequently not a good book. -- *Roy G. Van Driesche, Biological Control Specialist, Department of Entomology, University of Massachusetts, Amherst, MA.*

Innovative Approaches to Plant Disease Control. 1987. Edited by Ilan Chet. John Wiley and Sons, New York, New York. 372 pp.

This book is a landmark in the recorded history of plant disease control. It has fifteen chapters, each written by an outstanding research worker in some phase of the field. In large part, the investigations described have occurred in the past twenty years, although in some cases the origin of the research is traceable to an earlier period. Some of the work has resulted in currently practical control methods, although in other approaches this goal has not yet been attained.

Persons likely to be especially interested in the book include practicing plant pathologists and others who, for one reason or another, have prior knowledge of plant diseases. Many investigators in aspects of plant pathology will find the book helpful.

A fascinating chapter written by Dr. Chet relates to the use of the soil fungus *Trichoderma* in the biocontrol of certain aggressive soil-inhabiting seedling-, root-, and vascular fungal pathogens. These highly destructive plant-attacking organisms belong to the genera *Pythium*, *Rhizoctonia*, *Sclerotium*, and *Phytophthora*. They kill seedlings as they emerge from the soil, they attack the roots of older plants, and they invade a plant's vascular system to cause wilts.

The *Trichoderma* work has a longer history than several other ventures described in the book. In a pioneering paper published in the journal *Phytopathology* in 1936, Weindling and Emerson reported that soil isolates of *Trichoderma* produced a substance in pure culture that inhibited several of the above-mentioned soil-borne plant pathogens. They suggested at the time that *Trichoderma* might eventually prove useful as a biocontrol agent. In 1989, after the publication of more than fifty research papers by several authors concerned with this basic idea, the envisioned goal now seems close to attainment. The limiting factor appears to be that rather large and somewhat costly amounts of the *Trichoderma* are required to attain good control, but this barrier presumably will be broken.

Other chapters, written by other authorities, are equally fascinating. A chapter by Dr. Jaacov Katan, for example, describes the heat killing of many kinds of soil-inhabiting root- and vascular fungal pathogens by the use of sunlight-transmitting plastic tarps placed on the soil surface.

Drs. R. J. Cook and D. M. Weller describe several methods for the control of the yield-decreasing take-all disease of wheat caused by the soil fungus *Gaumannomyces graminis*. The pathogen damages wheat roots, resulting in nutritional deficits and restriction of water movement to the tops of the plants. It survives between crops as a saprophyte on fragments of roots and stems from previous host plants. Several antagonistic competitors of the pathogen have been shown experimentally to control the severity of the disease. Fluorescing pseudomonads have been studied extensively in this connection.

A chapter by Dr. J. A. Thomson relates that many bacteria have strains capable of producing compounds called "bacteriocins" that can act against non-producing strains of the same organism. Such bacteriocin-producing strains have found application in the control of the bacterially caused crown gall of peaches.

The book is not, of course - and not intended to be - a summary of all recent developments in plant disease

control. It focuses instead on developments in which novel methods have been used.

Supporters of the goals of alternative agriculture may be interested and heartened to learn from the pages of this book the degree to which modern methods of dealing with plant diseases are moving toward methods that do not make use of agricultural chemicals. *-- P. B. Marsh, Consultant, Institute for Alternative Agriculture, Greenbelt, MD.*

FROM THE LITERATURE

Abstracted by William Lockeretz

Research reports

Rural well-being and agricultural change in two farming regions. Jere Lee Gilles and Michael Dalecki. *Rural Sociology* 53(1):40-55 (1988).

This paper investigates the "Goldschmidt hypothesis," the idea that the quality of life in agricultural counties is better where modest-scale family farming predominates. First proposed by Walter Goldschmidt in the 1940s in his study of two towns in California's Central Valley, this idea has since been examined many times, with conflicting results. Here it is applied to the Corn Belt and the Central Great Plains, for the period 1949 to 1970.

In explaining the design of their study, the authors note that there is a difference between the scale of farming and the structure of farming, so that Goldschmidt's original results may arise from the higher prevalence of tenancy and hired labor in the community with larger farms, not from the size of the farms. They also point out that a finding such as Goldschmidt's will not necessarily apply to regions with different farming systems, and that one must consider not only the agricultural structure at a given time, but also how it has evolved.

Consequently, this study uses as explanatory variables not only the prevalence of large farms in a county (Class I in the agricultural census), but also the proportion of full tenants and the average number of hired laborers per farm. It uses the values of these variables at the beginning of the study period and also uses their changes during the period. The measure of socioeconomic well-being for each county in 1970 is an index constructed from four variables: median income, proportion of male heads of household not in poverty, median education, and proportion of dwellings with complete plumbing. The analysis was done for all counties where agriculture accounted for at least 15 percent of the work force (227 in the Corn Belt and 119 in the Plains).

The results confirmed the hypothesis that there would be regional differences, so the two regions were analyzed separately. Multiple regression analysis showed that contrary to the Goldschmidt hypothesis, socioeconomic level was higher in counties where the proportion of large farms increased since 1949. It was significantly lower where the number of hired workers per farm had increased, and in the Great Plains only it also was significantly lower where the number of workers per farm had been higher in 1949. Change in tenancy during the period had no effect on socioeconomic level in either region.

In discussing their findings in relation to Goldschmidt's, the authors note the Corn Belt and Great Plains have very different agricultural characteristics from California's Central Valley. They believe that the relevant question is not how big the farms are, but who controls them. In the Midwest, increasing farm size in the study period did not necessarily imply a shift away from farms that were family owned and operated. However, it did imply a loss of population. This may in turn have led to a decline in the quality of community services, an issue that Goldschmidt considered but that was not dealt with here.

Effects of nitrogen fertilizer and weed control on nutritive quality of carrots (Daucus carota L.). K. S. Sandhu, A. K. Joshi, and K. L. Bajaj. *Plant Foods for Human Nutrition* 38:67-73 (1988).

This study investigated the effects of various levels of N fertilizer and different herbicide treatments on carrots' flavor, content of carotene (a precursor of Vitamin A), and total soluble solids. The experiment was done using a single commercial variety on a sandy loam soil low in organic C. In the first year, 12 weed control treatments were used that involved seven herbicides at various application rates, with some treatments including hoeing. Both weeded and unweeded non-herbicide controls were also tested. All treatments received the same inorganic fertilization (62.5, 30, and 75 kg/ha of N, P_2O_5, and K_2O respectively). In the second year, the only herbicide treatments were the three that gave the best results the previous year, all involving fluchloralin

applied preplant (at .9 or 1.2 kg of active ingredient/ha, the former both with and without hoeing). Weeded and unweeded controls were also used. All treatments received the same application of P and K, but N was varied from 0 to 80 kg/ha.

In the first year, of the 14 weed control treatments, fluchloralin applied at the higher rate gave the highest carotene level, 11.8 mg per 100 g fresh weight of carrots, in comparison to 9.6 and 4.7 mg/100 g for the weeded and unweeded controls respectively. A similar pattern was observed the second year for all N rates. Averaged over all N rates, carotene was twice as high at the higher fluchloralin rate compared to the weeded control, and three times as high as the unweeded control. In the second year, carotene increased with increasing N for all weed control treatments, averaging almost double with 80 kg N/ha compared to no applied N. Therefore the highest carotene level (16.2 mg/100 g) was observed at the highest N application (80 kg/ha) and the higher fluchloralin level (1.2 kg/ha). The lowest carotene level (2.8 mg/100 g) was for the unweeded control with no N. Similar results were obtained for total soluble solids, which again was highest for the higher fluchloralin rate in the first year, and for the higher fluchloralin and highest N rate the second year.

The taste panel judged the carrots on a scale from 1 (poor) to 4 (very good). Fluchloralin at the higher rate was judged best the first year, but the difference compared to the weeded control (3.63) was not significant. However, the unweeded control was noticeably poorer (2.46). In the second year, taste was comparable for all weed control treatments except the unweeded control, which was significantly poorer. N application had no effect on the taste ratings.

The authors surmise that the differences in carotene and total soluble solids with herbicides may have been due to the herbicides' effects on metabolic pathways, depending on the chemical structure of the particular herbicide. Another factor may have been exhaustion of soil N by weeds, which would account for the poor quality of the unweeded controls. However, this mechanism could not account for the entire effect, since the weed-free controls were intermediate between the unweeded controls and the best herbicide treatments.

Nitrogen transfer from forage legumes to grass in a systematic planting design. Laura S. Brophy, G. H. Heichel, and M. P. Russelle. *Crop Science* 27:753-758 (1988).

The usual way that a legume's nitrogen fixing capability can be used to benefit non-legumes is for the legume to be plowed down (either the entire growth or the residue after harvest). As it breaks down it releases N. However, a legume can also transfer N to another crop while it is still growing. Thus grass benefits from being raised in a mixed stand with a legume forage such as alfalfa. Little is known about the amount of N transferred from legumes, since any observed change in the N content of grass when it is grown with a legume could also be due to competition between the two species.

This study, conducted at the Rosemount Experiment Station in Minnesota, measured this process by adding nitrogen enriched in the isotope N^{15} to the soil. The degree of isotopic enrichment in the grass indicates the proportion of N taken up from the soil as opposed to the N transferred after having been fixed by the legume, since the latter source has the naturally occurring isotope ratio.

The study had four purposes: to determine the amount of N transferred from a legume forage to grass; to determine how the rate of transfer varies with the distance between legume and grass and with the ratio of the two species in the stand; to compare two species of legume forages; and to determine how the presence of grass affects the legume's N fixation.

Reed canarygrass was grown in a mixed planting with either alfalfa or birdsfoot trefoil. To permit carefully controlled spacing, all species were first grown in the greenhouse and then transplanted into rows with a fixed ro spacing and fixed spacing betwee plants in the row. The intermingling grass and legume varied from 5 adj cent rows of grass to 1 row of gra per 4 rows of legume. The stands we harvested three times, with only t above ground growth sampled.

The N content of grass generally i creased with increasing legume/gra ratio. The fraction of N in the gra that was transferred from the legum increased during the season, with t maximum at the third harvest. Th fraction also increased with increasi legume/grass ratio, plateauing whe the ratio was between 2:3 and 4:1. Th highest transfer rate was observed f the third harvest of the trefoil/gra stand, for a legume/grass ratio of 3: Under these conditions, the N tran ferred from the trefoil accounted f 79 percent of the N content of t grass. This corresponded to 17 perce of the N fixed by the trefoil. For gra grown with alfalfa, the maximum o tained by transfer was 68 percent (13 percent of the total fixed by alfalfa Some transfer was observed at least a distance of 20 cm (3 rows in th experiment). In four of the six gras legume species combinations, max mum N fixation occurred in the legum row most surrounded by grass (le ume/grass ratio 3:2).

Regarding the high proportion of that the grass obtained by transfer, t authors note that the soil initially w low in N and suggest that a legum grass ratio of at least 1:1 would be be eficial for pasture production on l N soils. The presence of grass in tu benefits the overall N balance by sti ulating N fixation. This probably ha pens because the grass depletes the s N. Soil nitrate inhibits N fixation, sin the legume has no need to expend e ergy for N fixation when N is read available in the soil. The authors es mate that fixing the N transferred the grass reduced the accumulation dry matter in the legume by 7 and percent for alfalfa and trefoil resp tively.

Sustainability requires broad cultural effort

In a previous letter (Amer. J. Alt. Agric. 4:1, 43, 1989) I reviewed some concerns regarding the present state of the public and scientific discussion of agricultural sustainability (or rather *agrosustainability*). In the intervening months I have continued to notice the myopia of technical investigators in this field. Sustainability cannot be achieved through scientific efforts alone; it must be built through broad cultural efforts. *Sustainability requires that each system is uniquely coevolved with highly aware and evenly equanimitable stewards.* That is, sustainable systems arise in conjunction with the cultural evolution of the human community.

Another idea that I call "the ecological uncertainty principle" is instrumentally important to attaining sustainability. In short, no measurement of ecosystems can be made without altering them. As well, the management of ecosystems always involves unintended, and frequently harmful, though occasionally helpful, influences on those functioning systems. So, in managing ecological systems (the role of agriculture), we must be ever wary and ever flexible, ready to adjust to the unexpected and the unforeseen. This means managers have to learn to "fly by the seat of their pants," not "by instruments." Those scientists and technicians who think they can create agrosustainable systems by some kind of interchangeable-parts, mass-production approach will probably be sorely disappointed.

I believe that the road to agrosustainability (or, for that matter, cultural sustainability) will be built and followed well by people who create accurate "inner ecologies," that is, ecologies of mind (Gregory Bateson, *Steps to an Ecology of Mind*, 1978) and who adopt as their guidelines not scientific paradigms but rather artistic and spiritual metaphors of the world. I believe this because the efforts of agriculturalists and their societies since the advent of the Industrial Revolution and even before have largely resulted in destructive and self-limiting methodologies. During the latter ages of human history, the faiths in science and technology have allowed purely economic and anthropocentric views to predominate. Those views reinforced the biases that convinced many people that natural resources and natural processes were limitless and invulnerable. Hopefully, most (or at least enough) of us have now begun to see these as fallacies and will begin to learn to know better.

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FmHA "buy back" loans linked to high-input farming

Some farmers with productive lands make a good living through effective management, high output of crops with a favorable market, and federal subsidies. But some who borrow to purchase land at a price exceeding its value for agriculture cannot repay their loans. So it was at a neighboring farm, recently auctioned. The "owner" had 350 acres, about one-third of it bottomland, loans on land and equipment of over $400,000, and interest payments of about $25,000 per year. FmHA bought the farm for $130,000, or $371.43/acre. This is the first step in a process that favors high-input agriculture.

The 1987 Agricultural Farm and Credit Bill provides that a farm foreclosed and purchased by FmHA must be offered first to the former owner as "lease back" or "buy back." If buy back, the purchase price would be the capitalized value as a farm, based on a return of 8 1/2 percent on the investment - $130,000 is near the price that FmHA would calculate currently in the case of the farm near mine. If the former owner doesn't have money, FmHA may provide a credit (loan). If offered by FmHA and accepted by the former owner, he is then obligated to pay interest at 8 1/2 percent and to pay back the principal over a term that can be as long as 40 years. These payments mean that there can be net income only when the land under discussion returns more than about $15,000 per year ($43 per acre per year). Consider the choices involved in managing the land to insure this income.

Low-intensity usage of rangeland involves cows that graze native grasses in summer and some tame pasture plus a supplement in winter. The cows produce calves for sale each year. If spouse and children share the work of watching and tending bovines, there could be time for garden and orchard with additional income, and the husband and/or wife can work off the farm as well. Such an operation on a small farm

LETTERS TO THE EDITOR INVITED

The AJAA welcomes letters, short or long, commenting on articles in this journal or sharing ideas likely to be of interest to other AJAA readers. Since our space is limited, we do reserve the right not to publish all letters or, at times, to publish only excerpts from them. To take part in this exchange of ideas, write to: Editor, AJAA, 9200 Edmonston Road, Suite 117, Greenbelt, MD 20770.

involves little money at risk and conserves soil and water, but it is apt to produce only about $25 per acre above inputs each year on the farm under discussion. That alone cannot pay for the farm and is not a basis for FmHA transferring the property to a new or former owner.

Large-input agriculture, by contrast, puts more money at risk, implies substantial use of chemicals, produces larger outputs in rough proportion to inputs, and holds a prospect of greater gains (and also greater losses).

FmHA will estimate the income that can be gained the high-input way and the corresponding farm value. By this path, our government encourages some farmers both to stay on the land and to practice high-input agriculture. There are many implications of this policy for the structure of agriculture, agricultural production, farm implement and chemical manufacture, and the nature and welfare of rural America.

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RESOURCES

Agricultural and Food Policy Decisions, Report No. 89-4 from the Economics Department of South Dakota State University, concludes that nearly 70 percent of South Dakota farmers and ranchers surveyed in 1989 think that federal farm policies should encourage reduced use of synthetic chemical fertilizers and pesticides. The same percentage also think that soil conservation and water quality compliance should be a condition for receiving farm program benefits and that the government should regulate certain farming practices and land uses to reduce water pollution. For information, contact the Economics Department, South Dakota State University, Box 504A, Brookings, SD 57007.

Educational and Training Opportunities in Low-Input/Sustainable Agriculture: A Directory, from the National Agricultural Library's Alternative Farming Systems Information Center, lists over 100 groups, colleges, and agencies nationwide who provide such opportunities. Request copies from the USDA, National Agricultural Library, AFSIC, Room 111, 10301 Baltimore Boulevard, Beltsville, MD 20705.

The New Organic Grower, by Eliot Coleman, is a manual of tools and techniques for the home and market gardener. Coleman is nationally recognized for his work with model small-scale farms in Vermont and Maine. The 320-page book covers everything from land purchase to management and harvest of crops. It is $19.95 (plus $2.50 postage/handling) from Chelsea Green Publishing Company. Send orders to A.I.D.C., 64 Depot Road, Colchester, VT 05446.

Farmer-to-Farmer Directory, from the Sustainable Farming Association of Southeast Minnesota, lists 78 farmers willing to share their experience in using alternative farming techniques. The group ranges from conventional farmers just beginning the reduction of chemical fertilizers and pesticides to those using no synthetic chemicals in production. The directory is offered as a benefit of membership at $10/year. Contact the SFA, P.O. Box 53, 180 East Main Street, Lewiston, MN 55952, (507) 523-3366.

Farmland: A Community Issue, from Concern, Inc., is a citizens guide to farming practices and the ways in which sustainable agriculture can benefit everyone. An action guide, reference to pertinent legislation and examples of successful state and local initiatives are given. The booklet is $3 from Concern, Inc., 1794 Columbia Road, NW, Washington, DC 20009.

The Global Pesticide Monitor is a new newsletter of the Pesticide Action Network's North American Regional Center. The first issue carries a lead story on the current status of effects from the Bhopal, India, explosion that sent clouds of lethal gases through poor neighborhoods. It also covers export of pesticides, the World Bank pesticide policies, and other news. Subscription rates are $25 for individuals and non-profits, $50 for government or corporate institutions. Contact the PAN NA RC, P.O. Box 610, San Francisco, CA 94101.

Earth Ethics, a 16-page quarterly journal on "evolving values for an Earth community" provides short excerpts, book reviews, and current action in environmental ethics. It is edited by Sara Ebenreck, contributing editor to the *AJAA*, and is $10/year from the Public Resource Foundation 1815 H Street, NW, Suite 600, Washington, DC 20006.

Global Warming and the Future of Texas Agriculture is a report from the Texas Department of Agriculture that assesses the potential consequences of global warming for that state. Four of the five current global climate change models project less precipitation for Texas during winter months, suggesting serious consequences for available water supplies, the report says. Increased temperatures could make pest control an even greater problem than at present and force shifts in cropping patterns. Texas agriculture can make itself more sustainable by reducing its use of energy and of nitrogen fertilizers, the report recommends. It should aggressively adopt water conservation techniques and develop drought contingency plans. Overall ecosystem diversity should be restored or preserved. For more information, contact the Texas Department of Agriculture, P.O. Box 12847, Austin, TX 78711.

Midwest LISA Notebook, with information on cover crops, nutrient, weed, and disease management, tillage systems, livestock, and more is available (in limited quantity) for the cost of shipping and handling at $10. Make check payable to University Extension and send to the University Extension Center, Attn. LISA Notebook, P.O. Box 218, Greenville, MO 63944, (314) 224-3221, Ext. 31.

The Heifer Project Exchange is a free newsletter on appropriate small-scale livestock technology for a developing world. The last 26 issues are now available in book form for $15. Contact the Heifer Project International Exchange, P.O. Box 808, Little Rock, AR 72203.

Farm Bill 1990: Agenda for the Environment and Consumers, is a report from 11 national organizations that outlines environmental and consumer concerns in agriculture and proposes broad policy directions to respond to the issues. Specifically, the environmental/consumer/farm-related groups ask that farms be required to keep records on the use of pesticides and nutrients and be assisted in developing management plans to achieve economically viable reductions in those inputs. The report suggests that an Environmental Stewardship Program could purchase easements to protect wetlands and water quality and provide funding for pollution-preventing farm management strategies in priority areas. It calls for expanded research on sustainable farming systems and for reform of federal commodity and crop insurance programs to end obstacles to the use of crop rotations. Federal standards for organic foods and programs to develop markets for organic foods are also urged. The report is $6 per copy, with a minimum order of 5 copies and $2.50 postage/handling from Island Press. Call toll-free 1-800-828-1302.

Licking Creek Bend Farm Video, is a 12-minute program for city children on questions about food and farms. Children in a classroom are shown asking questions, and footage of the organic farm is used as background for the answers. The program was created by Pennsylvania's Licking Creek Bend Farm, which is involved in a project to help Washington, DC, inner city children learn about the sources of their food. It is $17.50 from Mike Tabor, 706 Erie Avenue, Takoma Park, MD 20912.

Agriculture and the Environment: A Study of Farmer Practices and Perceptions, from the American Farmland Trust, reports that upwards of three-quarters of farmers surveyed like the idea of changing commodity programs to permit crop rotations. The least popular policy options were those calling for regulatory approaches to prevent excessive use of farm chemicals. The Washington-based nonprofit group surveyed 500 farmers nationwide. The study also collected data on farmer use of practices often considered both environmentally and economically sound. For more information, contact the AFT at 1920 N Street, NW, Suite 400, Washington, DC 20036.

Organic Farmer, a digest of information on sustainable agriculture designed to build dialogue among organic farmers across the continent, is a new quarterly from Rural Vermont. The premier Winter 1990 edition features articles on the definition of organic products and the forthcoming national legislation on that matter. The publication is $10/year from Rural Vermont, 15 Barre Street, Montpelier, VT 05602.

Sensible Agriculture, a newsletter on low-input practices for farmers, features related news, research, practical information, and advice on cutting farm input costs. The first issue includes results from four on-farm research sites varying from soil tests to cut fertilizer use to fighting weeds by planting rye. Charter subscriptions for 12 monthly issues are $39 from Northcutt Communications, P.O. Box 1921, Bothell, WA 98041-1921.

Cover Crops for California Agriculture is a 24-page guide to selecting, growing, and evaluating cover crops. Contact Publications, Division of Agriculture and Natural Resources, University of California, 6701 San Pablo Avenue, Oakland, CA 94608-1239.

Copies are $5 (including postage) from JoAnn Collins, Department of Agronomy, University of Nebraska, Lincoln, NE 68583-0910.

Food chain group asks growers to disclose pesticides used on produce

Five small food chains in California, Arizona, Nevada, and Boston pledged to ask growers to disclose pesticides used on produce. By 1995 the chains have said they will stop selling fresh produce that has been treated with pesticides proven to be linked to risks of cancer. The chains are Raley's Supermarkets, Bread & Circus, Petrini Supermarkets, ABCO Supermarkets, and Provigo Distribution, Inc. Together they represent nearly 1200 supermarkets, says the *Washington Post* report.

Leopold Center holds conference for farmers and scientists

Farmers who are concerned about the costs and environmental implications of their farming practices made up about one-third of the more than 200 people at an early February conference sponsored by the Leopold Center for Sustainable Agriculture in Ames, Iowa.

In the early 1980s, people living on farms and in rural communities were in the middle of a debilitating farm crisis and wanted no part of methods that could jeopardize paper-thin profit margins. Farmers began looking for more efficient ways to cut back on production costs without lowering yields.

At the same time, contaminants began showing up in Iowa's ground water, and they were linked to agriculture's use of synthetic fertilizers and pesticides. While farm profits remained a primary focus, surveys began showing farmers' worries about the quality of water supplying their families and food animals.

In addition, rising farmer income in the last few years has shifted previous concerns from simply staying on the farm to preserving and enhancing the quality of the land and other natural resources.

Sustainable agriculture

Thus, sustainable agriculture, which offers profitable farming systems that conserve natural resources, drew a myriad-minded audience to the Leopold Center's conference. The first day farmers and conservationists listened to scientific research results on sustainable cropping and livestock management systems. The second day of the conference, farmers explained how they use sustainable practices to reduce production costs, maintain crop yields, conserve soil, and allay pollution fears.

"The general theme of the meeting was that mainstream farmers are beginning to look at sustainable agricultural systems, although there are still many details to work out," Dennis Keeney, Director of the Leopold Center, said. "The conference also showed that researchers are making significant steps toward developing sustainable practices that farmers can use."

"The view that sustainable agriculture is a path to lower farm income is false," said John Miller, a farmer from Cedar Falls, Iowa. "The economic value of sustainable agriculture is exemplified in Iowa's Butler County Project. This Integrated Farm Management program increased the profits of 50 farmers by a total of $500,000 in 1989. The $10,000 per farm indicates nearly a $5 return for each dollar invested or a $22 per acre increase in profits," Miller explained.

Ralph Neill, a farmer from Corning, Iowa, explained how cattle pastures help conserve soil on his highly erodible acres and add to his profits. He emphasized the importance of soil conservation to sustainability. "The world is losing 25 billion tons of topsoil per year," Neill said. "That is equal to all the topsoil under the wheat area in Australia."

Boone, Iowa, farmers Dick and Sharon Thompson have been experimenting with low-input farming systems since 1967. They explained in detail how they grow crops without herbicides in a ridge-till system, overseed fall cover crops into row crops, and produce livestock without antibiotics in feed or water.

Mark Honeyman, an animal scientist from Iowa State, offered sustainable alternatives to traditional swine production in the Midwest. He suggested changing swine diets to include more forages, using hogs to harvest crops or crop residue, multi-specie feeding systems, and feeding hogs low-trypsin s beans.

"The key to feeding pigs in a sust able system seems to be utilizing fe stuffs that complement human activi (by-product feeds) and that are deri from crops (forages) that are positiv the environment," he said.

Honeyman took a hypothetical ample of a 400-acre Midwestern far a corn-soybean rotation producing 2 head of hogs each year. If alfalfa substituted for 25 percent of the swine feed (210 lbs/ha/year), the c ation would need 70 acres in alfalfa

"Every acre cropped would be ir falfa once every five or six years," H eyman explained. "This change c have a tremendous impact on ferti needs, water quality, soil erosion, herbicide use."

Animal scientists Jim Russell f Iowa State and Ron Morrow from University of Missouri-Columbia ta about intensive rotational grazing of cattle. Morrow showed how contro grazing is an efficient use of forages, Russell outlined a year-round gra plan of legumes in a rotational sys on summer pastures and grazing c stalks or stockpiled residual forage ir fall and winter.

Louis Best, an animal ecologis Iowa State, discussed management cisions that benefit wildlife in agro systems, including tillage options, tir of mowing and burning, crop diver cation, and the spatial configuratio crop fields.

Richard Cruse, an Iowa State ag omist, described how strip intercrop with multiple crop rotations can su soil nutrients without relying on stock. Cruse found no decline in ov yield when legumes were incorpor into a strip intercropping system.

iculture is basically organized produc-
ion in a natural system, a system which
hrives on diversity," he said.

Charles Francis, an agronomist from
he University of Nebraska-Lincoln, told
he audience that to address agricul-
ure's effects on the environment and the
wareness of finite fossil fuel resources
ill require a major shift for those who
esign programs in research, teaching,
nd extension.

Conference attendees could choose to
articipate in three of eight open dis-
ussion sessions led by scientists and
armers. Discussion session topics were
rawn from conference presentations.

The meeting featured 35 posters of
esearch findings. Most of these projects
ere funded by the Leopold Center. Pos-
er topics ranged from nitrogen fertilizer
equirements for corn after alfalfa to bi-
logical suppression of the European
orn borer.

Center officially opens

The official opening of the Leopold
Center was held in conjunction with the
eeting, even though the Center began
s work more than two years ago. Iowa
tate University's Provost Milton Glick
aid, "We can now say this is a success
tory, a national focus for people con-
erned about the future of agriculture
nd the environment."

Nina Leopold Bradley, co-director of
esearch at the Leopold Memorial Re-
erve and Aldo Leopold's daughter,
howed powerful examples of the worn-
ut Wisconsin farm her family began to
estore in the 1930s and how it is now
overed with dense stands of trees and
rairie grasses.

"We have a long distance to go in the
nited States before soil regeneration
quals soil loss," she said. "This soil debt
something like the national debt and
far is being faced with about the same
uccess."

Charles Benbrook of the National Re-
earch Council's Board on Agriculture
elivered a comprehensive synopsis of
ow Leopold's writings, teachings, and
hought-provoking essays written more
han 40 years ago are still progressive
hought for modern-day agriculture. He
lso explained how farmers began mov-
ng to a more sustainable agriculture and identified key players and legislative actions that were involved.

One key speaker was Paul Johnson, a state representative from Decorah, Iowa, and one of the authors of the 1987 Iowa Groundwater Protection Act that created the Leopold Center. He explained that the act focuses on research, education, and demonstration. "The Leopold Center was established as the centerpiece of those activities for agriculture," he said.

"Today people ask who Aldo Leopold was and why a center at Iowa State was named after him. Those questions and the answers are an important and intentional part of the process," Johnson said.

"The role of the Leopold Center is not just to generate research results, but to encourage wise land use and show how it can be done profitably," said Director Dennis Keeney. "Obviously, this is a journey, not a destination. But it's a journey well worth taking."

Eileen Gannon Williams, Information Specialist, Leopold Center for Sustainable Agriculture, Iowa State University, Ames, IA 50011

Pheromones control grape berry moths, LISA research shows

Insect pheromones successfully competed with insecticides to control the grape berry moth on 100 acres of upper New York state vineyards last year, report Cornell University researchers T. J. Dennehy and J. P. Nyrop. The method involves attaching 200 pheromone "twisties" to selected vines in each acre. The sex pheromones disrupt mating of the moth, which is a major vineyard pest in that area.

At all sites in both the Lake Erie and Finger Lakes regions, the damage in pheromone-treated plots was well below the 2 percent level that the grape industry sets for allowable damage. At all but one site, the pheromones performed equally well or better than insecticides used in comparison plots.

The research is part of a multistate LISA-funded project. For more information, contact Dennehy and Nyrop at Cornell University, New York State Agricultural Experiment Station, Geneva, NY 14456.

Atrazine uses pores in soil to move to ground water, research shows

Atrazine, a leading corn herbicide frequently detected in ground water, was not predicted in its safety tests to move rapidly down in soils. But USDA scientists at the Natural Resources Institute in Maryland have shown that atrazine moves through holes caused by worms, decayed root channels, and cracks.

Using double ring infiltrometers and a bromide tracer, scientists Jim Starr and Dwight Glotfelty of the NRI Environmental Chemistry Laboratory demonstrated that most of the atrazine remained on the soil surface after a large addition of water. But they also detected some atrazine in all soil cores down to a 90-centimeter level during the same one-week period.

The findings have major implications for the potential of ground water contamination as well as for methods to reduce the movement of atrazine through soils, the NRI report says. The study was reported in the NRI newsletter for July 1, 1989. Contact the Natural Resources Institute, USDA-BARC, Beltsville, MD 20705.

(continued from page 99)

energy resources needed for fertilizer, chemicals, and fuels, for credit from commercial sources, and for capital and labor. Also, U.S. farmers compete for world markets and must adapt to changes in supply and demand for various commodities. Value-added products provide an economically attractive alternative to exporting only low-value, high-volume feed grains. This change in global focus is essential to the continued health of agriculture in the U.S. as long as the primary crops are feed grains and many markets are beyond national borders.

Another dimension of a globalized agriculture that often does not concern the U.S. farmer or commodity exporter is the impact of basic food imports on farmers overseas. When commodities are imported just before harvest, local prices may be depressed below the break-even level. If this disincentive to local production causes farmers to shift to cash crops or other pursuits, a region or country can become highly dependent on external sources of grain. The resulting harm to the national economy and food supply is beyond the control of the individual farmer and country.

The cost of food imports adds to an already difficult international debt. Although comparative advantage and production efficiency on a world scale make sense in a perfect world, that world does not exist. In the real world there are droughts, unstable world energy prices, trade embargoes, large debts and interest payments, highest bidders, and political alliances. In today's global agriculture and international food industry, there is good reason for every country to achieve a degree of self-sufficiency in basic grains. It also is important for exporting countries and their producers to respect the needs of farmers and governments everywhere.

Conclusion: Meeting these future challenges

Are we willing to pursue these challenges? Can we effectively limit population? Can institutions and individuals learn to face the real issues that will determine the earth's long-term ability to produce food and meet human needs? Will this be done in a resource-efficient way that preserves other options for future generations and within an ecological context that guarantees a reasonable quality of life for humankind everywhere?

The current sustainable agriculture debate has generated some of the right questions and reflects a broad concern about resource issues and ground water quality. Non-governmental, private research and development groups, and industry specialists are full participants in the debate about what a sustainable agriculture should be. This is an exciting time of change.

Geographic horizons have broadened so that farmers in Nebraska listen to weather reports from Brazil and Argentina and follow the markets in Europe and the U.S.S.R. There is concern about grain market grades, producing and exporting quality products, and varying production of specific grains and types for specialized markets. Debate on the U.S. farm bill considers global trade, competitiveness, and costs of production. Ground water issues take on regional dimensions, and more people express concerns about global climate.

Yet there is a long way to go. The economic plight of Midwest farmers is closely tied to that of producers in other major exporting countries. Exports to developing countries depe on their governments' decisions on how or whether to subsid domestic grain production and the U.S. government's decisi on whether to provide food or economic assistance. It is portant to respect the course set by other countries to m their long-term food needs without putting economic or po ical pressure on them to adopt a strategy that is only favora to U.S. exporters. For agriculture and the world economic or to be stable, the strategy needs to benefit all countries.

Hunger and food issues are not merely regional nor natio but global. Women's issues are really human issues. Politi stability that comes with participatory systems and resou equity benefits everyone in the long run, and environmen concerns affect everyone. Extravagant energy investments military hardware, personal transportation, short-lived creat comforts, and disproportionate benefits for a few favored tions do not promote long-term human species survival. F lowing a "business as usual" mentality and letting curr economic structures and negotiations "sort things out" will solve these challenges.

We must view ourselves as one species in a global ecosyst and as members of a global community, concerned about sources, environment, and the well-being of our descenda Increasingly, global interests must take precedence over tional and individual goals, and we need equitable methods establish these priorities. Can we make these major and n essary adjustments in thinking? Can we afford a sustaina agriculture? Indeed, we cannot afford any other type of ag culture! This is the only game in town. There is no ratio alternative to developing a sustainable agriculture. The hum species must mobilize its most creative talent to meet the ch lenge.

Note: The author expresses appreciation for the thoughtful and comprehensi comments from Dr. William Lockeretz, Technical Editor.

1990 Federal budget has $4.4 million for LISA Program

The FY1990 Federal budg signed by the President in Noven ber, 1989, has $4.45 million for th 1990 round of LISA grants. That the same amount as was allocate in the FY1989 budget. Accordi to Program Director Neill Schalle the budget only allowed support 13 percent of the eligible proposa in 1989. While interest in LIS projects has continued to grow, i funding still stays at the level of on half of one percent of the tot USDA research and education bu get.

Guide for authors

AJAA will publish original research on biological, physical, r social science aspects of alternative agriculture. We par-icularly welcome multi-disciplinary studies, but papers from specific discipline also are invited. However, since AJAA eadership is much broader than for a single-discipline journal, ighly specialized terminology should be explained or avoided. he significance of a statement, or the reasoning behind a onclusion, may have to be spelled out more than in a more pecialized journal. Research papers usually should be no nger than about 20 double-spaced pages.

lomenclature and technical details

Research papers should use the International (SI, or metric) ystem throughout. Write out "liters". "Metric ton", although ot strictly an accepted SI unit, can be used for data referring o "ordinary life," such as national crop output, as opposed o experimental data. Occasional use of common unit equiv-lents in parentheses is permitted, mainly for relatively exotic I units.

The binominal or trinominal designation of a plant or an-mal species, and the cultivar where relevant, should be given n parentheses the first time the common name of the species s mentioned. Either name may be used thereafter. The same pplies to names of chemicals that have both a common name nd a chemical name. Do not use brand names except where he chemical is produced under a unique brand name. In those ases the brand name, identified as such, may be given the irst time the chemical is mentioned. Nutrient applications hould be given in elemental form (N,P,K). Oxide forms can e used in describing commercial fertilizers.

itle page

The title page should give the following information (all lush left): 1) title of the paper; 2) names of authors; 3) af-iliation and office address of authors, and 4) acknowledge-nents, if any. See examples in this issue of AJAA.

bstract

The abstract should be 200 to 400 words suitable for readers rom a broad range of disciplines. It should avoid highly-pecialized terminology that might be appropriate for a single iscipline journal. Take particular care that the significance f the work is made clear, even to readers from a different ield.

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References should be listed in alphabetical order by author's ame, and by year for a particular author (with letters after he year if needed). If a sole author is also the lead author of apers with multiple authors, use the following order: single uthor (by year); two authors (alphabetically by second author's name); three or more authors (by year). Repeat the author's name for each reference. Use initials only for first and middle names. Give the names of all authors in the reference; never use "et al."

Use full names of journals, institutions, conferences, etc., except for extremely familiar abbreviations like "Dept." Remember that an abbreviation familiar to you may not be familiar to readers outside your field. If in doubt, write it out.

The reference list uses no quotation marks, italics, boldface, or underlining. Only the names of books and periodicals are in initial capitals. Names of papers, book chapters, pamphlets, and bulletins are not capitalized. Page numbers are written out in full (e.g., 1108-1123, not 1108-23). The volume is given if page numbers begin at 1 for each issue.

Citing references

Cite references in the text by last name and year, with chapter or page numbers if the reference is a book or lengthy report. For two authors, give both names. Do not use "et al." unless there are at least three authors.

Footnotes

AJAA does not use bibliographic or substantive footnotes. All bibliographic references should be at the end of the text. Instead of substantive footnotes, include the material in the main text or consider eliminating it.

Manuscript preparation

The entire manuscript, including abstract and references, should be typed on one side of standard-size paper, double spaced, with margins of at least one inch all around. Starting with the title page, label all pages in the upper righthand corner with the lead author's last name and the page number. Do not use hyphens unless the hyphen is part of the word. Do not underline anything except species names.

Follow the section headings style used in this AJAA issue. All headings are flush left, with no underlining or italics.

Tables should fit on one page, be numbered consecutively with Arabic numerals, and be on a separate sheet. Leave extra space to separate columns. Every figure and table should be mentioned at least once in the text.

Submission of manuscripts

Submit four high-quality copies to Editor, American Journal of Alternative Agriculture, Suite 117, 9200 Edmonston Road, Greenbelt, MD 20770. The cover letter should state that the manuscript is an original contribution that has not been published elsewhere in substantially the same form; that it is not currently under consideration elsewhere, and that permission has been obtained for any copyrighted material used.

How you can help support the scientific and educational needs of a sustainable agricultural system

A growing number of Americans have become concerned about the long-term sustainability of our food production system. Farmers and agricultural scientists are among those raising questions about the growing dependence of modern farming on nonrenewable resources, the depletion of our resource base through soil erosion, and heavy reliance on chemical fertilizers and pesticides. Continued heavy reliance on farm chemicals is questioned because they have become an expensive production input. Their widespread use also raises questions about human and animal health, food quality and safety, environmental quality, and the continued demise of the family farm.

Low-input alternative farming methods address these economic and environmental challenges. Alternative production systems point the way toward more profits, more individual choice, and long-term sustainability for our food system. More must be done to develop effective ways to make sure research, education, and information sources are readily available to farmers who want to adopt these techniques.

The Institute for Alternative Agriculture needs your help in meeting this challenge. We are a nonprofit tax-exempt research and education organization set up in 1983 to encourage and facilitate the adoption of low cost, resource conserving, and environmentally sound farming methods. We work directly with government agencies, colleges and universities, producer groups, and other institutions that provide research, education and information services to farmers.

The Institute also provides these services:

- *A resource to lawmakers and others who influence agricultural research, education, and information policy*
- *A voice for alternative agriculture in Washington*
- *A sponsor of research and education outreach programs*
- *A national clearinghouse for information on alternative agriculture*
- *A publisher of reliable scientific information on agricultural sustainability*

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